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INFORMAL REPORT

A COMPARISON OF SYNOPTIC TEMPERATURE-DEPTH OBSERVATIONS IN THE TONGUE OF THE OCEAN, BAHAMAS

MARCH 1968

NAVAL OCEANOGRAPHIC OFFICE
WASHINGTON, D. C. 20390

INFORMAL REPORT

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ABSTRACT

Comparisons of two sets of data collected in the Tongue of the Ocean (TOTO), one from the fixed-site AUTEC Environmental Monitoring Array at Site 2, the other from varying-site, on-station drops of the Shipboard Oceanographic Survey System (SOSS) from aboard the USNS SILAS BENT (AGS-26), were made for 3-7 January and 27 February through 4 March 1966. The comparisons reveal that both of these highly automated systems complement one another very well, despite the different approach each one takes to oceanographic sampling. Because the SOSS offers the advantage of horizontal flexibility, sampling locations of the "fish" were spaced at varying distances from the array in order to derive significant information on horizontal temperature gradients in the TOTO.

This report summarizes the results of these synoptic temperature-depth data comparisons and briefly discusses the significance of the data comparisons in terms of horizontal temperature gradients in the TOTO.

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This report has been reviewed and is approved for release as an UNCLASSIFIED Informal Report.

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INTRODUCTION

During the periods 3-7 January 1966 and 27 February through 4 March 1966 the USNS SILAS BENT (AGS-26) conducted oceanographic measurements in the Tongue of the Ocean (TOTO), Bahamas. The observations were made primarily for the operational evaluation of the BENT'S various oceanographic subsystems and in particular the on-station multiple sensor fish for continuous profiling of temperature, salinity, and sound speed versus depth. In addition, sampling locations were selected so as to provide synoptic data adjacent to, and at varying distances from an existing taut-wire array of temperature and pressure sensors installed as an environmental monitor in the Atlantic Undersea Test and Evaluation Center (AUTEC). It was intended that data from either system would help in the evaluation of the other and in determining the lateral variations in the TOTO. This report summarizes the results of the two sets of synoptic temperature-depth data and briefly discusses the significance of the data comparisons in terms of horizontal temperature gradients in the TOTO. Considerable attention is devoted to a discussion of the time variations of temperature as recorded by the array sensors during the observation periods. These time variations are not only of intrinsic interest but bear heavily upon the validity of comparing synoptic data of this type.

SYSTEM DESCRIPTIONS

The AUTEC array is a vertical array of temperature and pressure sensors located in 900 fathoms of water eight miles from, and cable-connected to shore facilities at Salvador Point, Andros Island, Bahamas. Twenty-four temperature and pressure sensors are distributed at fourteen depth levels as shown in the diagram in Fig. 1. Pressure sensors are located at three upper levels and temperature sensors are located at all levels. Paired temperature sensors are located at seven alternate levels for increased system reliability. Sampling of each sensor level is accomplished sequentially from the top sensor downward. A complete scan of all sensors requires approximately 80 seconds and a complete scan can be repeated as frequently as every two minutes. Each data record is referenced to a time base controlled by a digital clock synchronized with a WWV receiver.

The Shipboard Oceanographic Survey System (SOSS) on-station system employs a multisensor unit (fish) with a single sensor unit for each parameter. It employs a high scan rate which enables

each of five sensors to be interrogated every two seconds. At a lowering rate of 60 meters/minute, it is thus possible to sample approximately every two meters of depth thereby providing essentially continuous depth profiles for each parameter. Each and every scan of the data sensors is referenced to a time base controlled by a digital clock.

SAMPLING PROCEDURES

Both systems are highly automated, high data rate sensor systems. Both employ similar temperature and pressure sensors with FM cable telemetry and real-time data display in metric units. Both store data in digital form on magnetic tape. However, the systems are also different in that each is based on a different philosophy of oceanographic sampling and each has advantages or disadvantages which derive from the basic sampling approach.

The AUTEC array is anchored to the bottom and therefore each of its sensor levels is fixed relative to the sea floor. Vertical and/or horizontal sensor displacements are kept within small limits by the upward tension of the subsurface buoy. The virtues of this system are that it permits ordered time studies along a vertical profile of fixed points. The disadvantages lie in the limited number of sampling points with a resultant sacrifice of profile detail and a relatively high degree of sensor immobility and inaccessibility. Once installed, sensor locations are essentially fixed and sensor recalibration is almost impossible.

The advantages of the SOSS system are its ability to provide continuous profiles with no loss of microstructure and a high degree of system flexibility with respect to horizontal and vertical sampling. Sensor calibration and repair are also easily achieved. The major disadvantage is that it is not practical for long-term observations because it is tied to a surface vessel. Secondly, its output data do not lend themselves to thorough and detailed time studies even for short periods because of the uncertainties associated with sensor locations and because data sequences are essentially non-synoptic.

In spite of their inherent differences, data from the two systems complement one another very well. Thermal microstructure which went undetected by the AUTEC array was observed by the SOSS fish and, with a detailed knowledge of thermal profile, many of the peculiarities in the time variations recorded by array sensors were more readily understood. Moreover, the detailed definition of the thermocline and other thermal features permitted far more informed judgment on the agreement or lack of agreement between temperature-depth observations from the two systems.

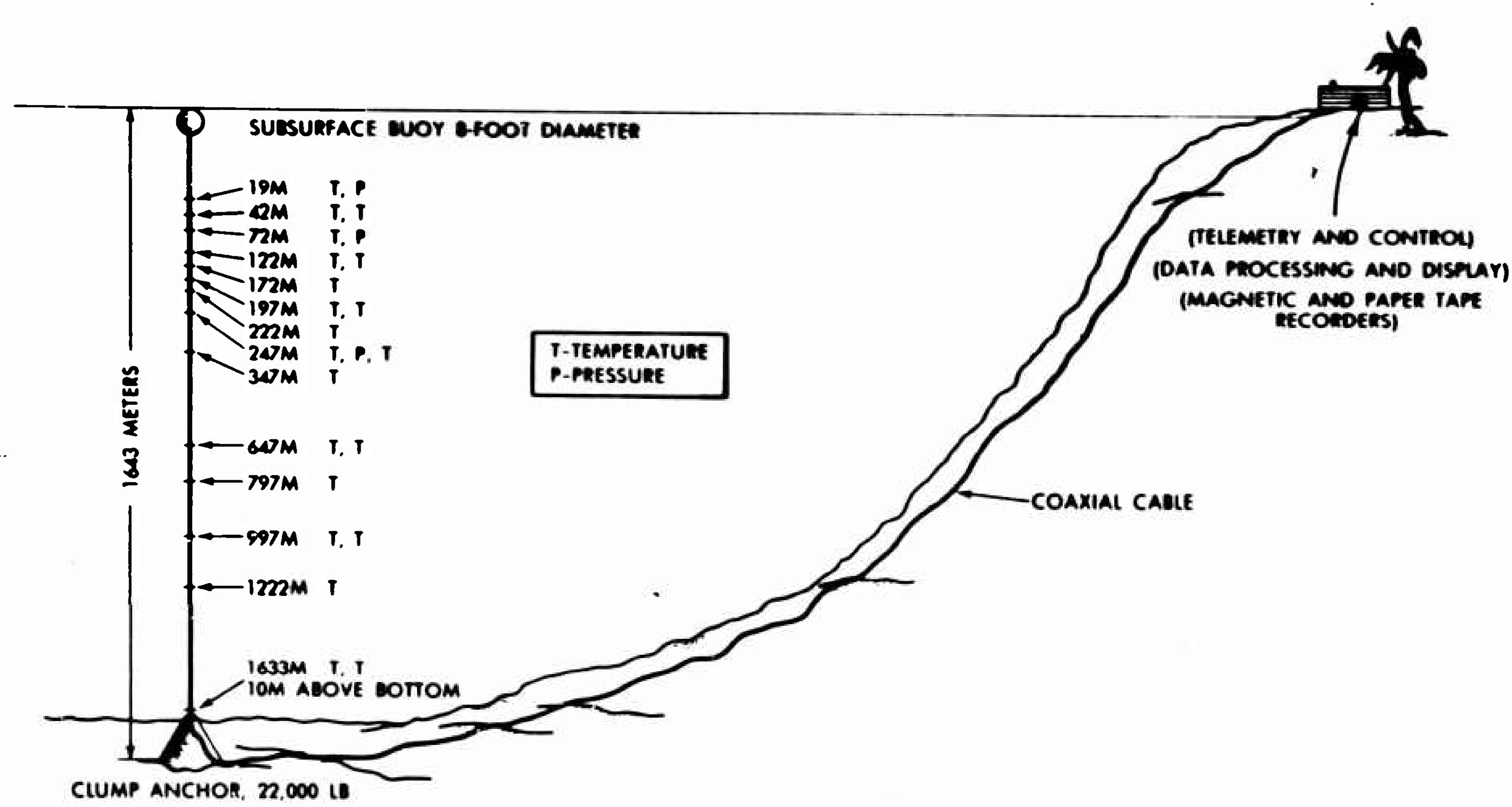


FIGURE 1 AUTEC ENVIRONMENTAL MONITORING ARRAY

DATA ANALYSIS

Station locations and the position of the AUTEC array are shown in Fig. 2. Temperature values from the SOSS data were determined by linear interpolation for the depths which corresponded to sensor level depths on the AUTEC array. Only values from the lowering of the fish were used as there was some question as to the accuracy of depth values on the raising of the fish. Simultaneous data from the corresponding array sensor levels were then used for the comparison. Since array data were collected every two minutes, the maximum time discrepancy is approximately one minute. There are some SOSS data for which no synoptic array data were taken because of array shutdown for malfunction or maintenance. There are also some SOSS stations for which data were obtained only during raising of the fish. Where considered, these data are so noted.

RESULTS

Differences between simultaneous temperature values are shown as a function of horizontal separation for each sensor level in Figures 3 through 5. The data are also presented in a different format in Appendix I where differences are plotted for each depth for each series of observations. Positive differences indicate that SOSS values were greater than array temperatures; negative values, vice versa.

January

Differences for levels 1, 2, and 3 were generally positive and less than 0.2°C. along the north-south track. Large negative differences occurred along the east-west track. Values were nearer zero for stations near the array but appeared slightly greater along the axis and considerably greater across the TOTO.

At levels 4 and 5, differences were generally negative. At level 4, the average difference was approximately -0.4°C for stations near the array whereas it was about -0.1°C for level 5. Negative values exceeding 1° were found across the TOTO and at the southernmost station for level 5.

At levels 6, 8 and 9 near the array, differences were generally less than 0.1° and did not show a pronounced positive or negative bias. Larger negative values occurred to the south along the Tongue and differences across the Tongue were larger still.

At levels 10 and 11, differences were consistently positive with the exception of a single station across the Tongue (No. 10),

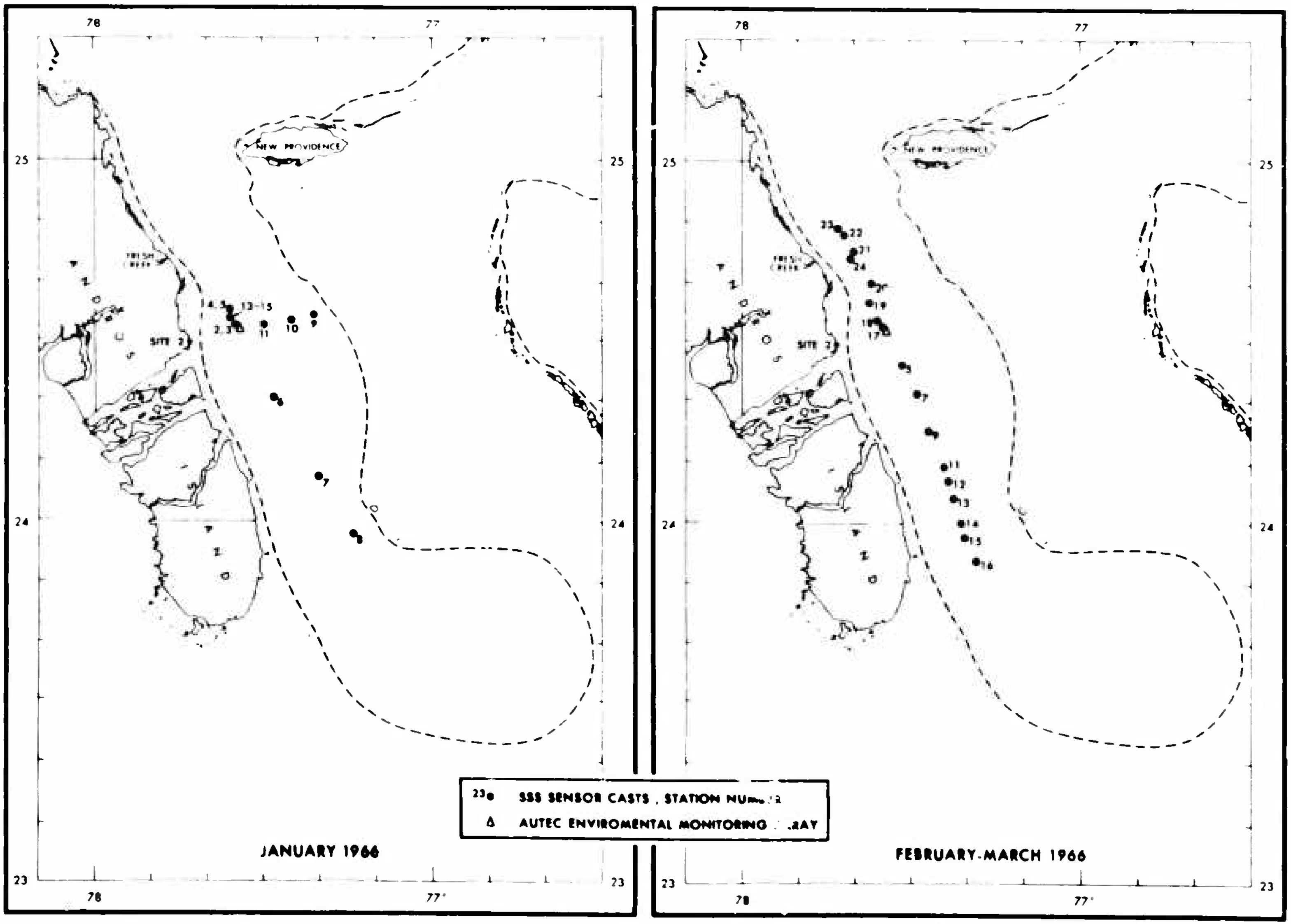


FIGURE 2 STATION LOCATIONS FOR SHIPBOARD SURVEY SYSTEM AND AUTEC ENVIRONMENTAL MONITORING ARRAY IN THE TONGUE OF THE OCEAN

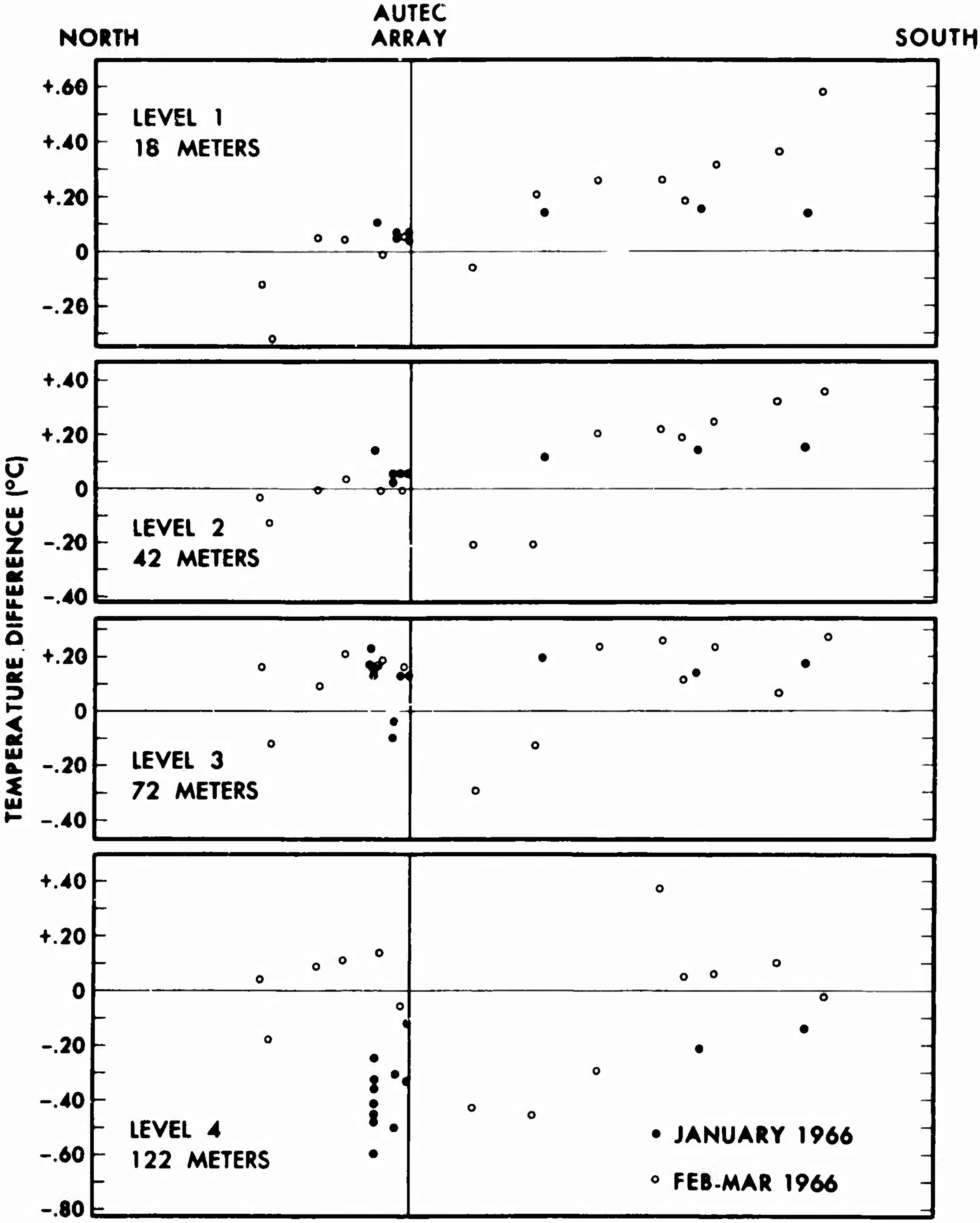


FIGURE 3 DIFFERENCE BETWEEN SIMULTANEOUS TEMPERATURE-DEPTH VALUES: SHIPBOARD SURVEY SYSTEM MINUS AUTEC ARRAY

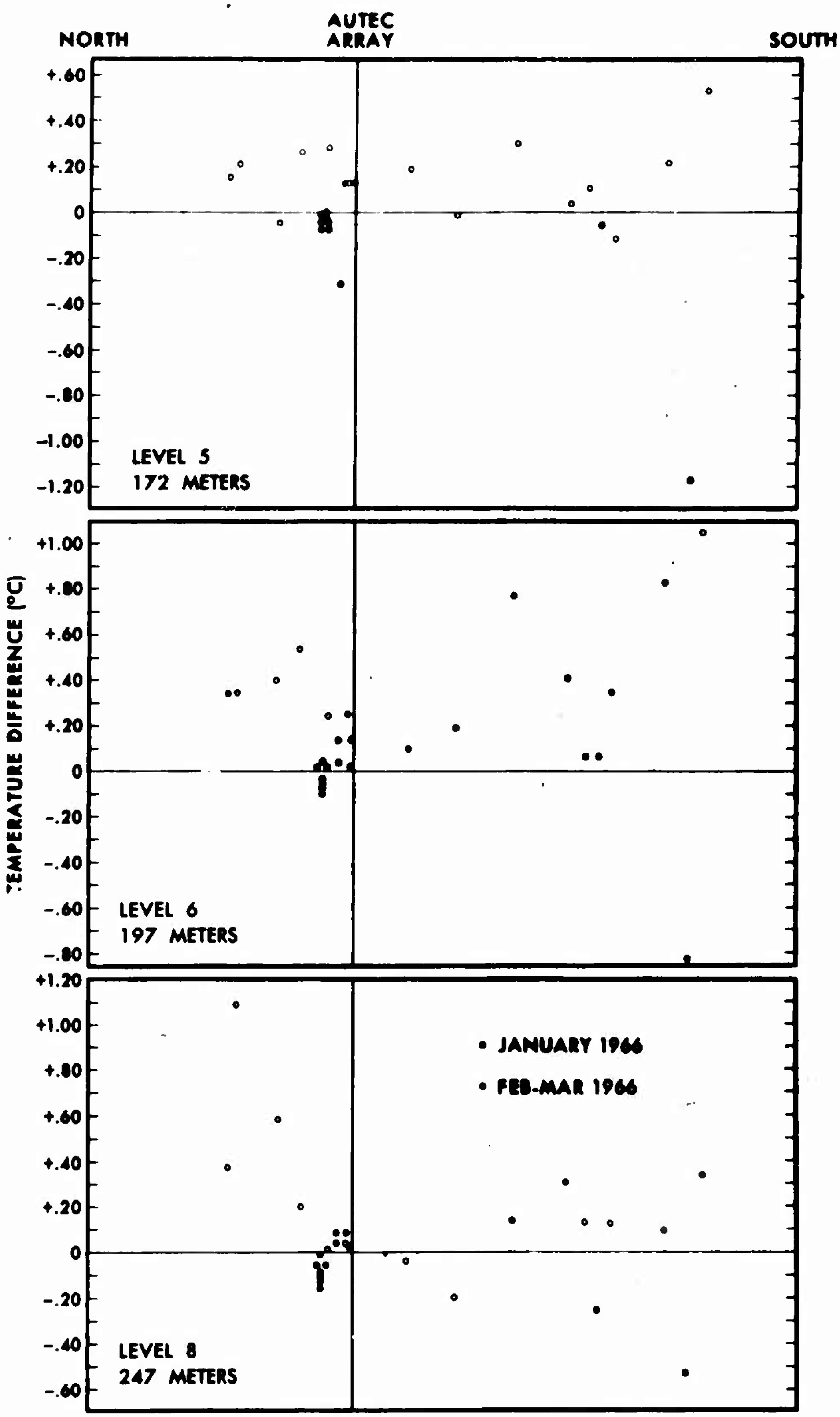


FIGURE 4 DIFFERENCE BETWEEN SIMULTANEOUS TEMPERATURE - DEPTH VALUES: SHIPBOARD SURVEY SYSTEM MINUS AUTEC ARRAY

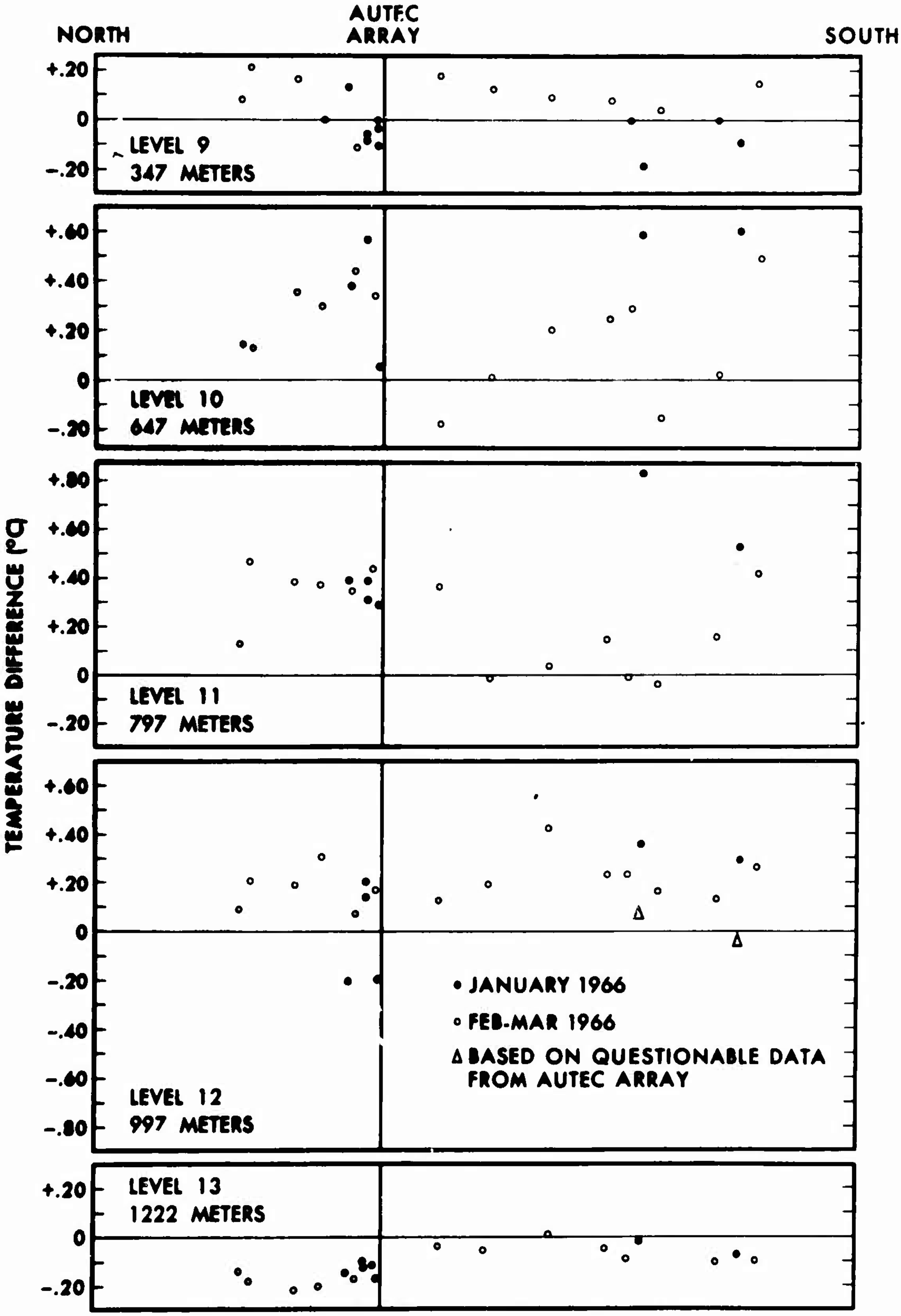


FIGURE 5 DIFFERENCE BETWEEN SIMULTANEOUS TEMPERATURE-DEPTH VALUES: SHIPBOARD SURVEY SYSTEM MINUS AUTEC ARRAY

where the difference was only -0.01°C. Values near the array averaged approximately +0.3°; those more distant across and along the Tongue averaged +0.5°.

Values from level 12 were not considered because of erratic temperature data from the AUTEC array.

At level 13, differences were always negative but tended to become less negative to the south. Across the Tongue there was only one reliable comparison with a value approximately equal to the difference noted along the TOTO.

February-March

For levels 1 and 2, differences for stations near the array were generally near zero but increased positively to the south and increased negatively to the north. The two stations immediately south of the array (No. 5 and No. 7) showed significantly large negative values at level 2.

Values at levels 3 and 4 showed considerable scatter and no definite positive or negative bias. Differences for the more distant stations were approximately the same magnitude as those for stations near the array. Large negative values occurred for stations 5 and 7 immediately south of the array.

At level 5, differences were generally positive and had no apparent change in magnitude with distance from the array.

At level 6, differences were consistently positive and large (+0.4° average). Values for stations near the array appeared significantly smaller and values appeared to increase to the south.

Differences for level 8 were generally positive and greater to the north than to the south. Values were smallest for stations adjacent to the array.

At level 9, differences were nearly all positive and averaged about 0.1°. There was no significant difference in values for stations near to or distant from the array.

At levels 10, 11 and 12, differences were generally positive and had no discernible trends with respect to magnitude of values and station distance from array.

At level 13, differences were negative with the exception of one small positive value (Station No. 9). Differences for stations

to the north were, on the average, 0.1°C greater in magnitude than those to the south.

Tables 1 and 2 list the individual differences for each series of synoptic observations along with mean values and standard deviations at each depth level. In general, differences for both sets of data were largest at levels 4 through 8 and 10 and 11; differences were smallest for levels 1, 2, 3, 9, and 13. The greatest variability in synoptic observations (largest standard deviations) and the larger mean differences were commonly associated with the depth levels where vertical temperature gradients were largest i.e., levels 4 through 8, 10 and 11. Differences for stations near the array were generally less than those for stations more distant along a given direction. Differences across the Tongue were much greater than along the Tongue.

DISCUSSION

Observational Accuracy

The accuracy of SOSS temperature measurements was checked over the full temperature range on several occasions during the January measurements. Checks were made by reversing thermometers attached to the sensor fish and righted at known times while the sensors were in operation. These checks showed the temperature sensor to be very accurate. There was of course no independent accuracy check for array sensors but some measure of sensor accuracy could be inferred from the close agreement of temperature values from paired sensors at several depth levels. The mean differences between dual temperature readings at levels 2, 6, 8, and 10 for January data were +0.04, -0.05, -0.04, and +0.01°C, respectively. Comparable differences for the latter data were +0.33, -0.07, -0.08, and 0.00°C. The large change for sensors at level 2 was caused by drift of one sensor (sensor 2) before ultimate failure several weeks after the March observations. Differences for level 4 sensors were nearly 0.2°C but showed negligible drift between the two periods of observations. Of the two temperature readings at level 4, data from the primary sensor (No. 1) are believed to be more accurate.

The accuracy of array temperature measurements cannot be fully resolved; however, the precision of these data was comparable to the precision of the SOSS temperature data neglecting differential effects of the sampling procedures involved. The accuracy and the precision of the reference depth values for each set of data are more important for a meaningful comparison of synoptic data. Array sensor depths are believed known to one or two meters down to and including level 8. Pressure data have corroborated

TABLE I DIFFERENCES IN SYNOPTIC TEMPERATURE-DEPTH OBSERVATIONS FOR SHIPBOARD SURVEY SYSTEM AND AUTEC ENVIRONMENTAL ARRAY: JANUARY 1966

SENSOR LEVEL NO.	STATION NUMBERS 2	3	4A	4B	4C	4D	4E	4F	5	6	7	8	9	13	14	15	n	$\bar{X}$	σ
1	.04	.05							.10	.15	.14	-.28	-.11		.05	.06	9	.02	.14
2	.05	.05							.14	.14	.15	-.36	-.09		-.05	-.03	9	.00	.16
2	.02	.03							.11	.12	.13	-.38	-.11		-.07	-.05	9	-.02	.16
3	.14	.14	.17		.17	.16	.15		.23	.15	.17	-.57	-.12		-.09	-.03	13	.05	.22
4	-.12	-.34	-.49	-.61	-.46	-.42	-.34	-.25	-.36	-.21	-.14	-1.30	-.20		-.51	-.31	15	-.40	.29
4	.05	-.16	-.31	-.44	-.28	-.25	-.17	-.09	-.13	-.05	-.08	-1.14	-.03		-.34	-.14	15	-.24	.28
5	.13	.13	-.02	0	-.04	-.07	-.01	-.07	.04	-.05	-1.17	-1.31	-.49		-.31		14	-.23	.46
6	.14	.02	.02	-.10	-.07	-.04	.04	.02	-.11	.07	-.83	-.78	-.38		.14	-.06	15	-.13	.30
6	.18	.06	.06	-.06	-.02	.01	.09	.07	-.06	.12	-.77	-.73	-.33		.19	-.01	15	-.08	.30
8	.09	.03	-.01	-.09	-.13	-.11	-.16	-.06	-.06	-.25	-.53	-.42	-.14		.08	.04	15	-.12	.18
8	.14	.08	.04	-.05	-.09	-.07	-.11	-.01	-.02	-.21	-.48	-.38	-.10		.12	.08	15	-.07	.18
9	-.10	.03							.14	-.18	-.09	-.28	.11		-.06	-.07	9	-.06	.13
10	.06								.39	.60	.50	.75	-.01		.58		7	.41	.29
10	.05								.39	.59	.49	.74	-.01		.58		7	.40	.28
11	.28								.38	.82	.52	.46	.01	.38	.30		8	.39	.23
12*	-.58								-.76	.07	-.04	.07	-.04	-.05	0		8	-.17	.32
12	-.18								-.21	.36	.29	.31	.13	.14	.20		8	.13	.22
13	-.17								-.15	-.01	-.07		-.14	-.12	-.11		7	-.11	.05

*ARRAY DATA ERRATIC DURING THESE OBSERVATIONS

n no. of pairs of observations
$\bar{X}$ mean difference
σ standard deviation of the differences

TABLE II DIFFERENCES IN SYNOPTIC TEMPERATURE-DEPTH OBSERVATIONS FOR SHIPBOARD SURVEY SYSTEM AND AUTEC ENVIRONMENTAL ARRAY: FEBRUARY—MARCH 1966

SENSOR LEVEL NO.	STATION NUMBERS																
	21	20	19	18	17	16	15	13	12	11	9	7	5	24	n	$\bar{\Delta}$	σ
1	-.12	.05	.04	-.01	.05	.59	.37	.32	.19	.26	.26	.21	-.06	-.33	14	.13	.23
2	-.04	-.01	.03	-.01	-.01	.36	.32	.25	.19	.22	.21	-.21	-.21	-.13	14	.07	.19
2	.29	.31	.36	.32	.33	.70	.66	.62	.52	.57	.54	.13	.09	.22	14	.40	.20
3	.16	.09	.21	.19	.16	.27	.07	.24	.11	.26	.24	-.14	-.29	-.12	14	.10	.17
4	.05	.09	.11	.14	-.06	-.02	.10	.06	.05	.38	-.30	-.46	-.44	-.18	14	-.03	.24
4	.24	.29	.31	.33	.13	.17	.30	.25	.16	.57	-.11	-.26	-.24	.02	14	.15	.23
5	.16	-.05	.26	.28	.13	.53	.22	-.11	.11	.04	.30	0	.19	.21	14	.16	.16
6	.34	.41	.54	.25	.25	1.05	.83	.35	.06	.41	.77	.19	.10	.35	14	.42	.29
6	.41	.48	.61	.31	.32	1.12	.90	.41	.14	.48	.84	.28	.16	.41	14	.49	.29
8	.37	.59	.20	.01	.04	.33	.09	.12	.13	.30	.14	-.20	-.04	1.09	14	.23	.32
8	.43	.67	.28	.09	.11	.41	.16	.20	.20	.39	.30	-.10	.06	1.15	14	.31	.31
9	.09	.17	0	-.11	0	.15	0	.04	0	.08	.09	.13	.18	.22	14	.07	.09
10	.14	.35	.30	.44	.33	.49	.02	-.16	.29	.25	.20	.01	-.18	.13	14	.19	.21
11	.13	.38	.37	.34	.43	.41	.15	-.04	-.01	.14	.03	-.01	.36	.47	14	.23	.19
12	.08	.19	.30	.07	.16	.26	.13	.16	.23	.22	.42	.19	.12	.20	14	.20	.09
13	-.14	-.22	-.20	-.17	-.12	-.10	-.10		-.09	-.05	.01	-.05	-.04	-.18	13	-.11	.07

n no. of pairs of observations
$\bar{\Delta}$ mean difference
σ standard deviation of the differences

array dimensions for the upper section but there are no measurements to substantiate the cable dimensions below level 8. Throughout the array, precision of depth measurement is unimportant as the sensors are fixed. Depth accuracy for the SOSS fish is known to be very good (about 1 meter) above 500 meters but thermometric depth checks made during the January observations indicated that systematic errors (about 15 meters) were present below 500 meters. No depth accuracy checks were made during the latter observations.

In any case the precision of the depth measurements for both systems is thought to be sufficient to permit a useful comparison of the synoptic temperature data providing that the greatest significance is attached to the relative differences rather than their absolute differences. In other words, because the depth errors are systematic and because vertical gradients do not generally vary greatly laterally at a given depth, it can be assumed that significant and orderly changes in the synoptic differences do in fact reflect lateral temperature changes or sloping isothermal surfaces.

Time Variations

A consideration of the time variations recorded with the AUTEC array is necessary to any discussion of the comparative measurements made by the two systems. However, the temperature-time sequences recorded during the SILAS BENT January operations are extraodinary in their own right. They demonstrate with amazing clarity the presence of tidal temperature variations down to depths of several hundred meters. They also show that higher frequency fluctuations occur at most depths and that some of these fluctuations are quite probably internal waves.

Time sequences for three different time scales are shown in Figures 6, 7, and 8. In the first sequence (Fig. 6), data for three sensor levels are shown for the 17-day period from 25 December 1965 through 10 January 1966. Fig. 7 shows on an expanded scale that portion of the record which covered the period of BENT'S January observations. Figure 8, in turn, shows a four-hour segment of the Fig. 7 sequence, again on an expanded scale so that the shorter period changes are more evident.

The 17-day record of Fig. 6 shows the tidal variations and some larger fluctuations whose extremes span several days. The tidal period is particularly marked for level 6 from about 3 January to the end of the record. It is noted that the largest tidal extremes occur between one and three days after full moon on 7 January. Tidal extremes for the 7-day record are least during the three days preceding quadrature on 31 December. Extreme

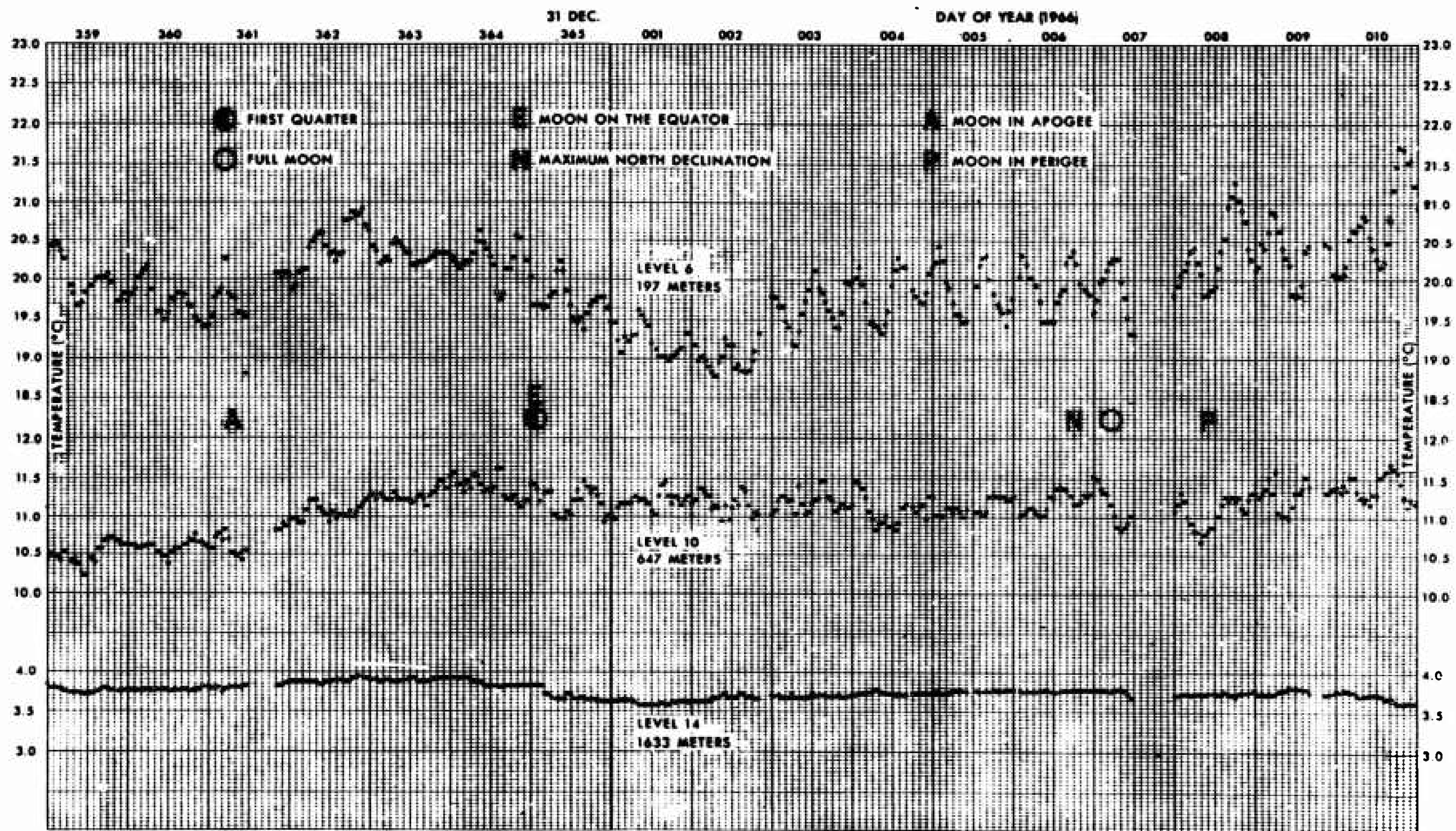


FIGURE 6 17-DAY RECORD OF HOURLY TEMPERATURE OBSERVATIONS FROM AUTEC ENVIRONMENTAL MON TORING ARRAY

temperature variations for the 17-day record were 3.0, 1.6, and 0.3°C for the three levels, respectively.

Figure 7 shows in more detail the temperature variability occuring at most array sensor levels. Levels 2 and 3 are omitted because the data are similar to level 1; level 12 is omitted because of erratic sensor behavior. The most striking feature of this four-day record is the cyclic behavior of the temperature sequences for levels 4 through 9 (122 through 347 meters). Fluctuations are also prominent at levels 10 and 11 but their character is not visibly periodic. Level 1 shows broad periodic variations with maxima occuring about 1700 hours each day. This is very probably the result of the daily warming and mixing of surface water.

In addition to the temperature records, Fig. 7 shows pressure fluctuations recorded by the shallowest pressure sensor on the array (19 meters). These are shown superposed on a tide record made at the shore station with a bubbler tide gage. The jitter of the array pressure data during the first three days is caused by wave action which diminished considerably by 7 January. The good agreement between the two records offers strong evidence for the depth stability of array sensors. One interesting feature of Figure 7 is the asymmetry of the temperature record for level 4. At first glance this might appear to reflect asymmetry in the internal tide which is not prominent in the surface tide. However, closer study of the temperature maxima and especially the vertical temperature profile measured by the BENT reveals a much more plausible explanation. During the observation period, level 4 coincided closely with the top of the thermocline (see Figure 9). Upward motion of the thermocline merely caused temperature changes determined by the displacement and the temperature gradient which was generally uniform below about 120 meters. Downward motion caused the depth of the mixed layer to temporarily exceed the level 4 sensor depth and resulted in an effective maximum limit for temperatures at this sensor level. The resultant temperature-time sequence displays truncation or "clipping" of the temperature maxima which can be seen to parallel roughly the temperature of the mixed layer.

Internal Waves

Figure 8 is an enlargement of a four-hour data sequence taken on the morning of 4 January. The data generally coincide with the "turn" of the internal temperature tide and show more clearly the nature of the short-period changes which occur in the TOTO. Several of the levels display fluctuations which have "periods" of from one-fourth to one-half hour. The frequency of variations appears to diminish with depth and the amplitude appears to vary

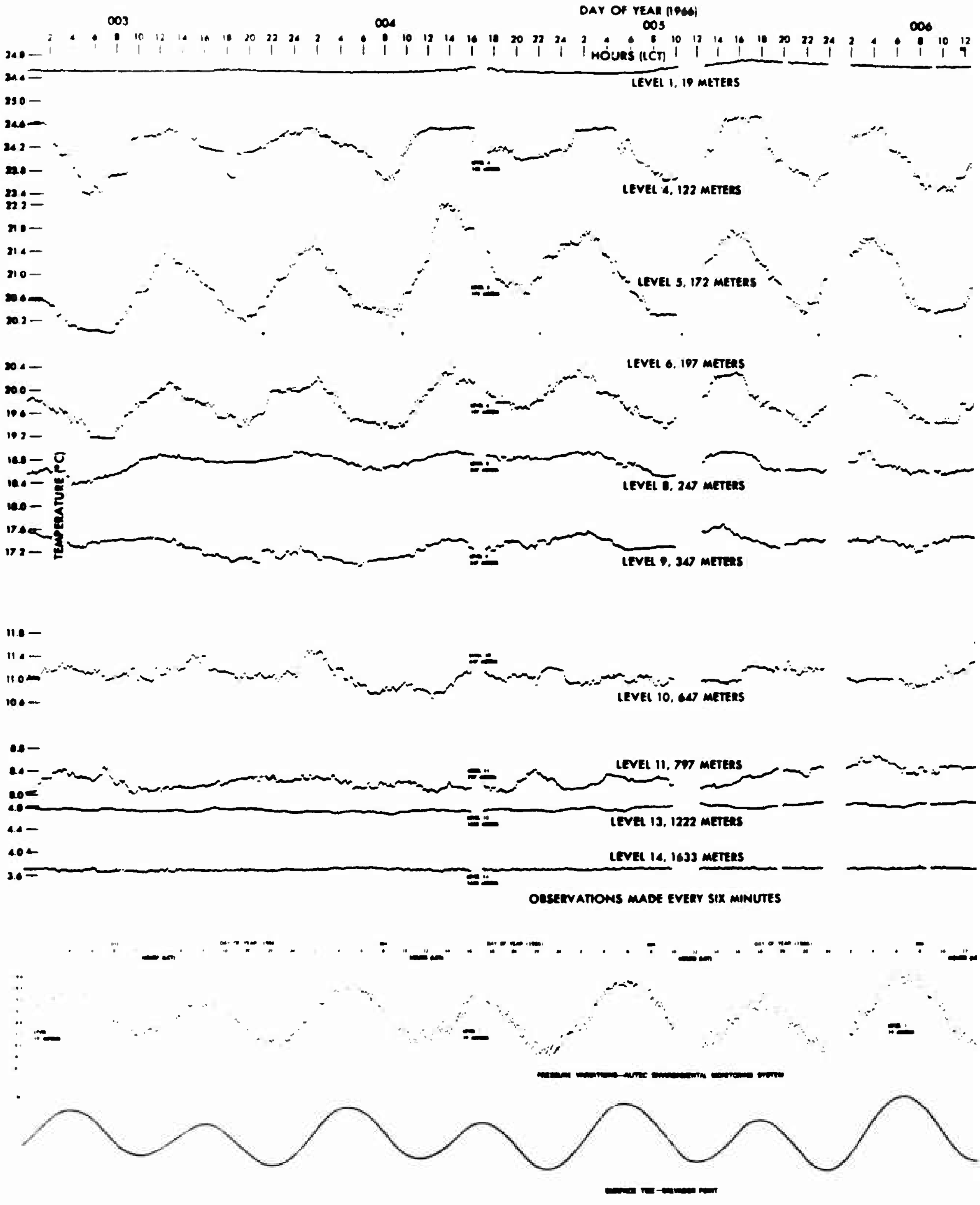


FIGURE 7 4-DAY RECORD OF TEMPERATURE OBSERVATIONS FROM AUTEC ENVIRONMENTAL

A

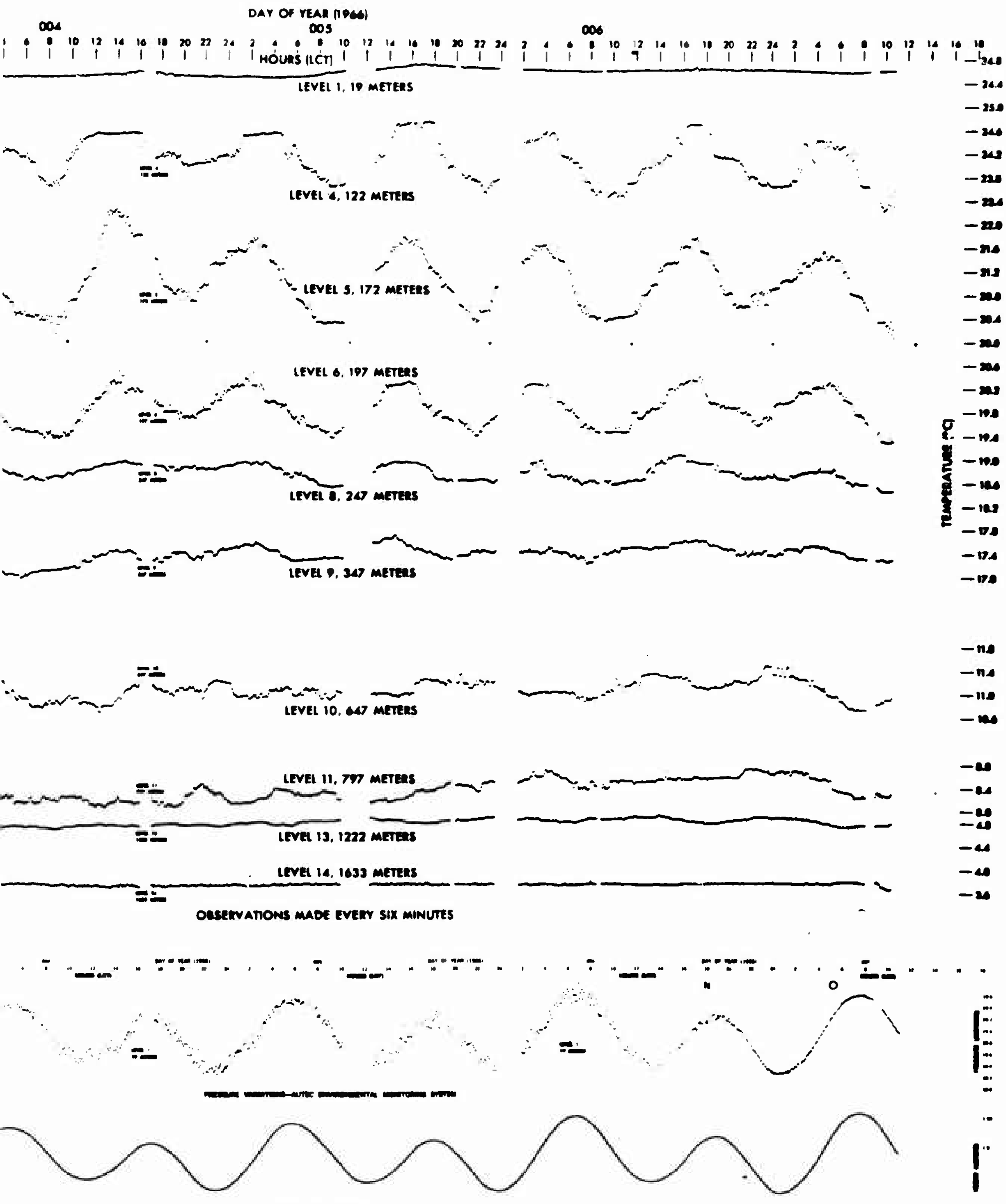


FIGURE 7 4-DAY RECORD OF TEMPERATURE OBSERVATIONS FROM AUTEC ENVIRONMENTAL MONITORING ARRAY

B

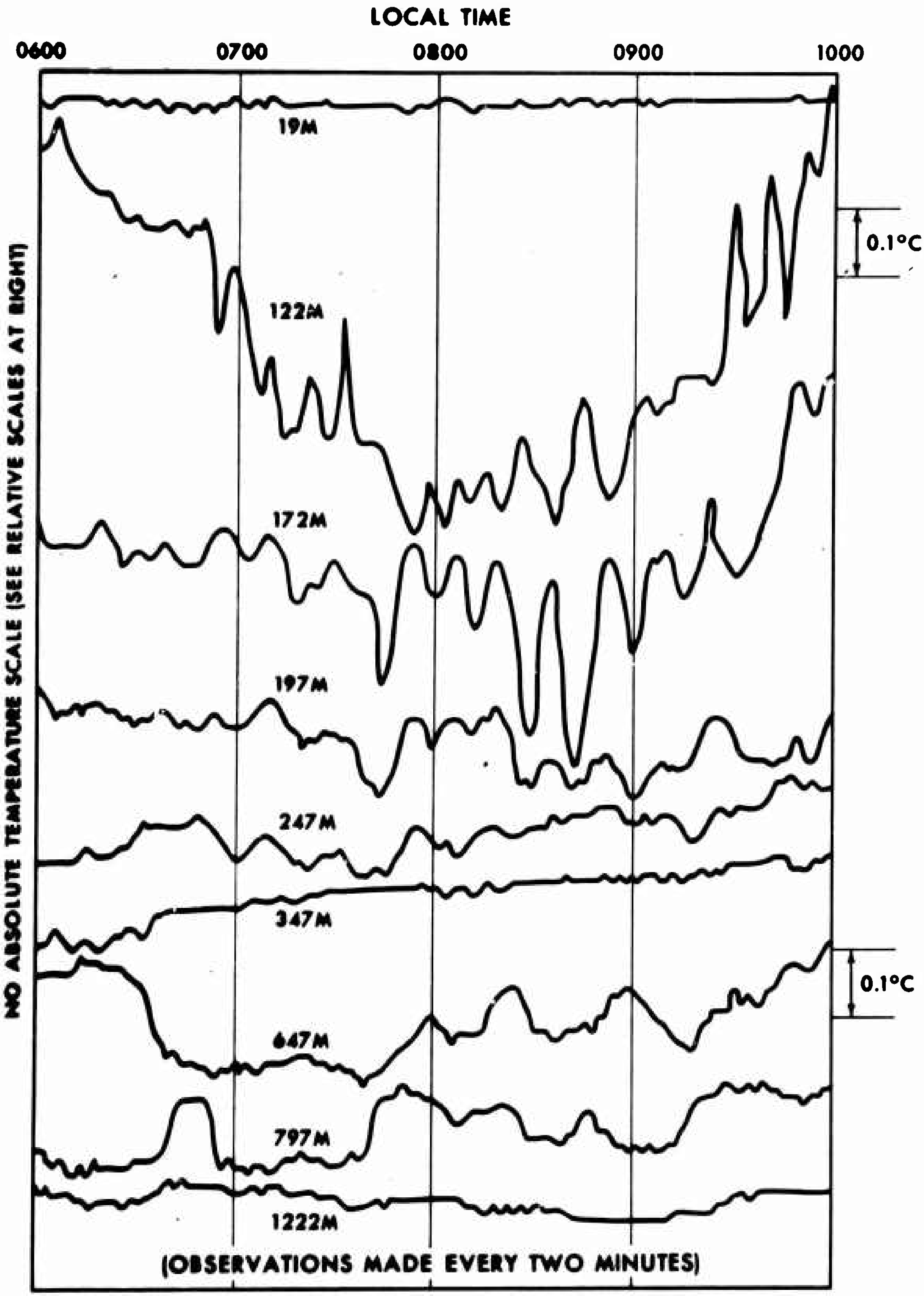


FIGURE 8 4-HOUR RECORD OF TEMPERATURE OBSERVATIONS FROM AUTEC ENVIRONMENTAL MONITORING ARRAY

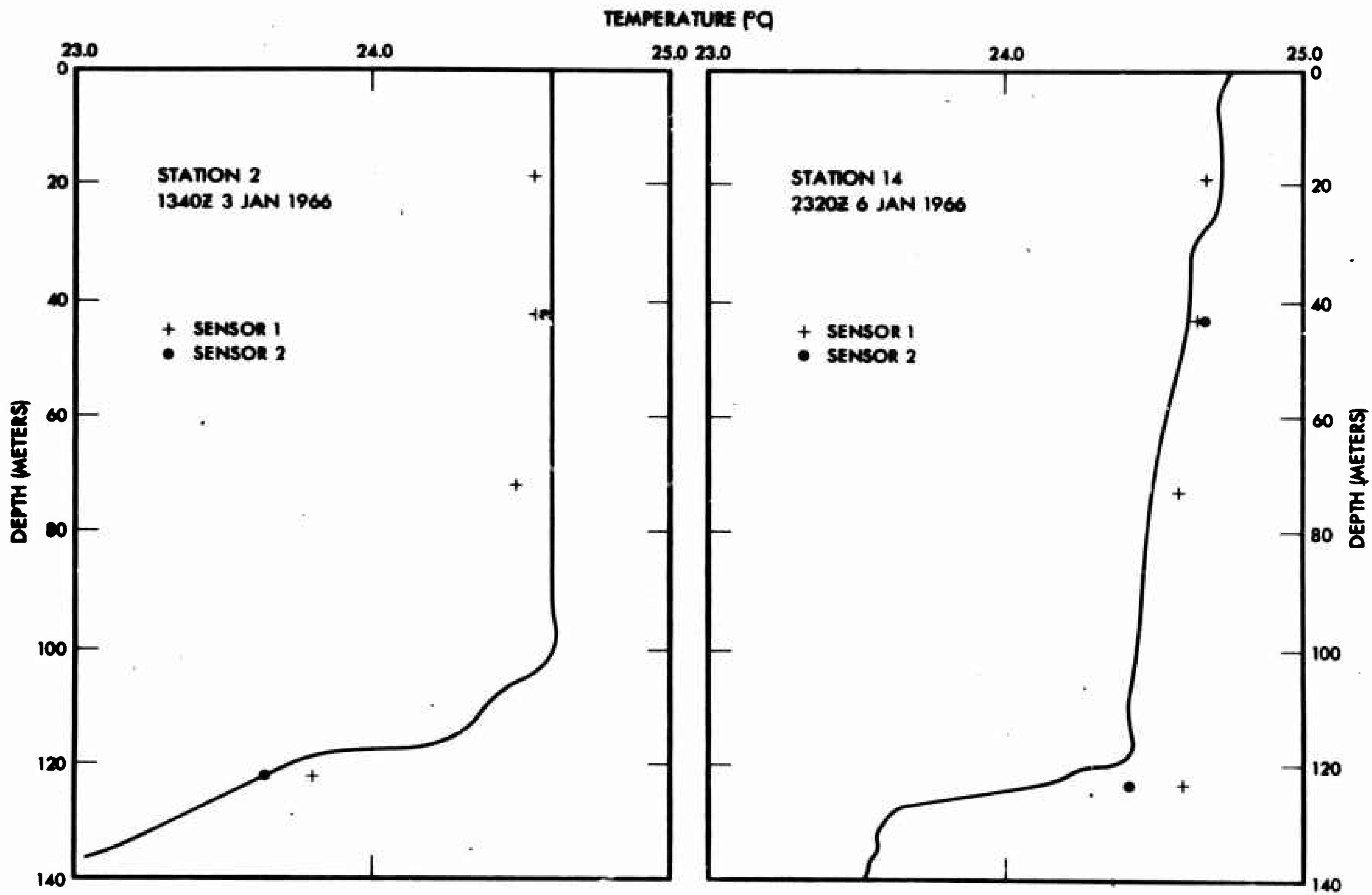


FIGURE 9 TOTO TEMPERATURE PROFILES NEAR THE BEGINNING AND END OF SILAS BENT OBSERVATIONS—JANUARY 1966

irregularly with depth. Levels 4 and 5, especially from 0800-0900 hours, are opposite in phase and strongly suggest the presence of an internal wave with a discontinuity surface between the two levels. An interesting speculation regarding this is that the discontinuity surface coincides with the salinity maximum which generally occurs very near the top of the thermocline.

Thermal Microstructure

In addition to the difficulties posed by time variability and observational inaccuracies, the determination of lateral gradients is also complicated by thermal microstructure. For example, compare the two profiles taken in January (Figure 9) with four profiles taken during March (Figure 10). The first January profile (Station 2) shows a remarkably isothermal layer 100 meters deep; the second profile (Station 14) shows that some irregularities have developed in the 3-day period but that the profile still remains generally smooth. In contrast, the March profiles in Figure 10 show numerous irregularities many of which are located at depths closely approximating the sensor depths on the AUTEC array. Since the dimensions of the microstructure are generally small compared to the horizontal separations involved, it is readily seen that simultaneous temperature-depth observations may often reflect local changes in the microstructure rather than lateral temperature gradients. In fact, unless lateral gradients are very pronounced and/or horizontal distances are generally great, it may be extremely difficult to get meaningful data on lateral gradients from only a limited sample of synoptic data.

SUMMARY AND RECOMMENDATIONS

Comparisons of synoptic temperature-depth observations indicate that lateral temperature gradients do occur in the TOTO. However, because of the complex interaction of time and space variability and the effects of sensor depth errors, it is possible to determine these gradients only qualitatively.

Differences in synoptic temperature-depth values were found to generally increase with increasing horizontal separation and with the magnitude of the vertical temperature gradient.

Synoptic data reveal positive temperature gradients to the south in the surface layers which may vary considerably in magnitude from season to season. Limited observations indicate that gradients across the TOTO are considerably stronger than along the TOTO.

Future experiments to determine the nature of lateral temperature

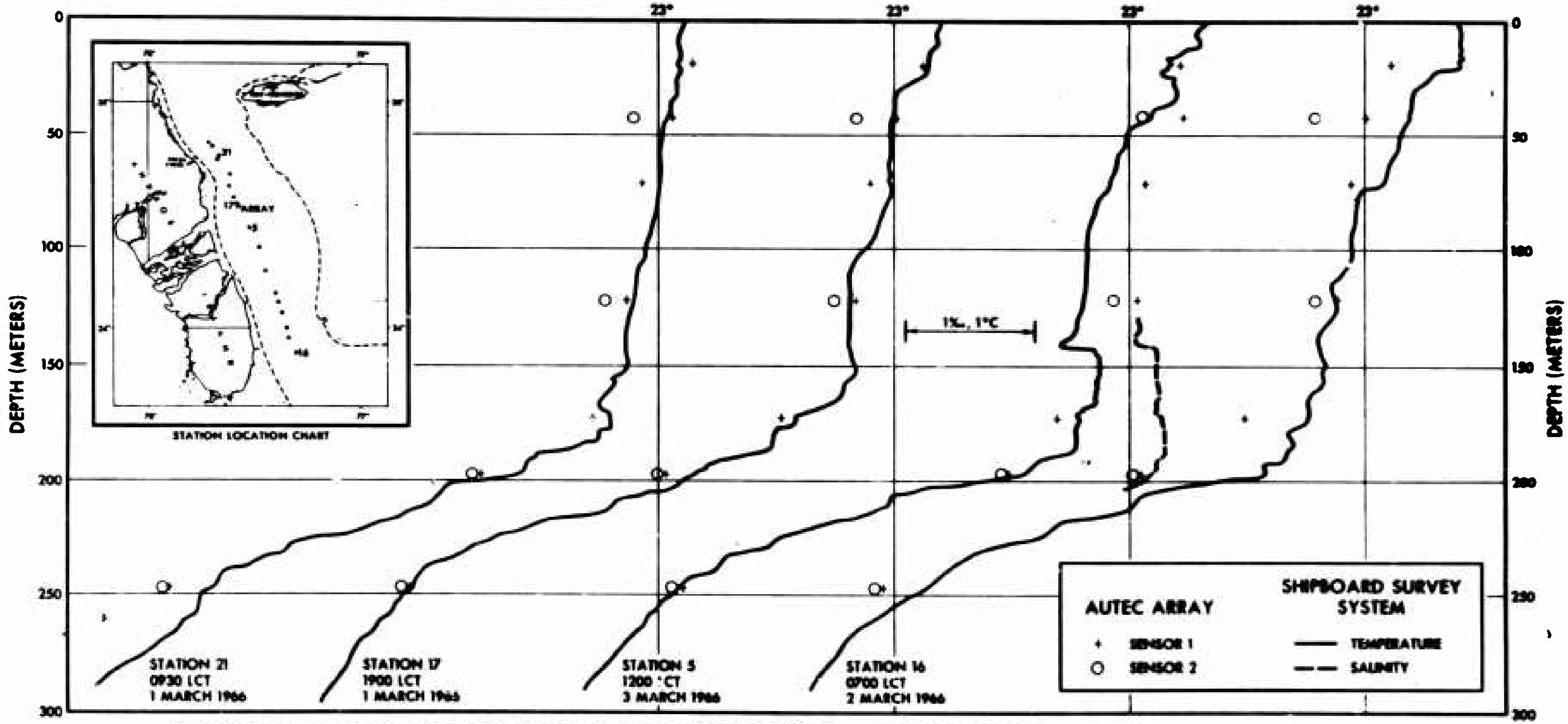


FIGURE 10 TEMPERATURE-DEPTH OBSERVATIONS — TONGUE OF THE OCEAN, BAHAMAS

changes in the TOTO must employ much larger data samples. Through the use of larger samples, the random effects of microstructure will be reduced. Larger samples and data averaging will also tend to cancel the effects of higher frequency time variations at the sampling points. The data required for this approach to the problem are now being collected from two new environmental arrays installed at AUTEC sites 1 and 7. Data from this network will permit synoptic comparisons based on temperatures averaged over various time intervals. With the random and oscillatory effects of microstructure and internal waves more effectively reduced, more reliable information on lateral gradients will be forthcoming. The only serious problem remaining will be the absolute accuracy and stability of temperature sensors as there is presently no way of calibrating them after installation. This problem will not be satisfactorily solved until submersibles are suitably outfitted with similar sensors for comparison measurements <u>in situ</u>.

Although there are several uncertainties associated with the comparison of simultaneous observations from a fixed array and ship-suspended sensors, this approach will be necessary and useful for some time. In the first place, as far as AUTEC applications are concerned, the basic problem is how well do the array measurements define the environmental parameters needed for range tests. For example, in acoustic tracking the essential parameter is sound speed integrated over large segments of the water column. Although the effects of thermal inhomogeneities and of high frequency variations may be significant in the comparison of discrete temperature-depth observations, these effects will be largely self-cancelling as measurements are integrated vertically. Thus, for example, series of velocimeter drops in the vicinity of the array may show that integrated sound speed profiles obtained from the former compare favorably with profiles derived from the array temperature observations. Numerous measurements of this type will be needed to "calibrate" fixed arrays and validate their usefulness for range environmental applications.

APPENDIX

DIFFERENCES BETWEEN SIMULTANEOUS TEMPERATURE-DEPTH VALUES

EXPLANATION OF SYMBOLS FOR APPENDIX

● Station Location (Shipboard Survey System)

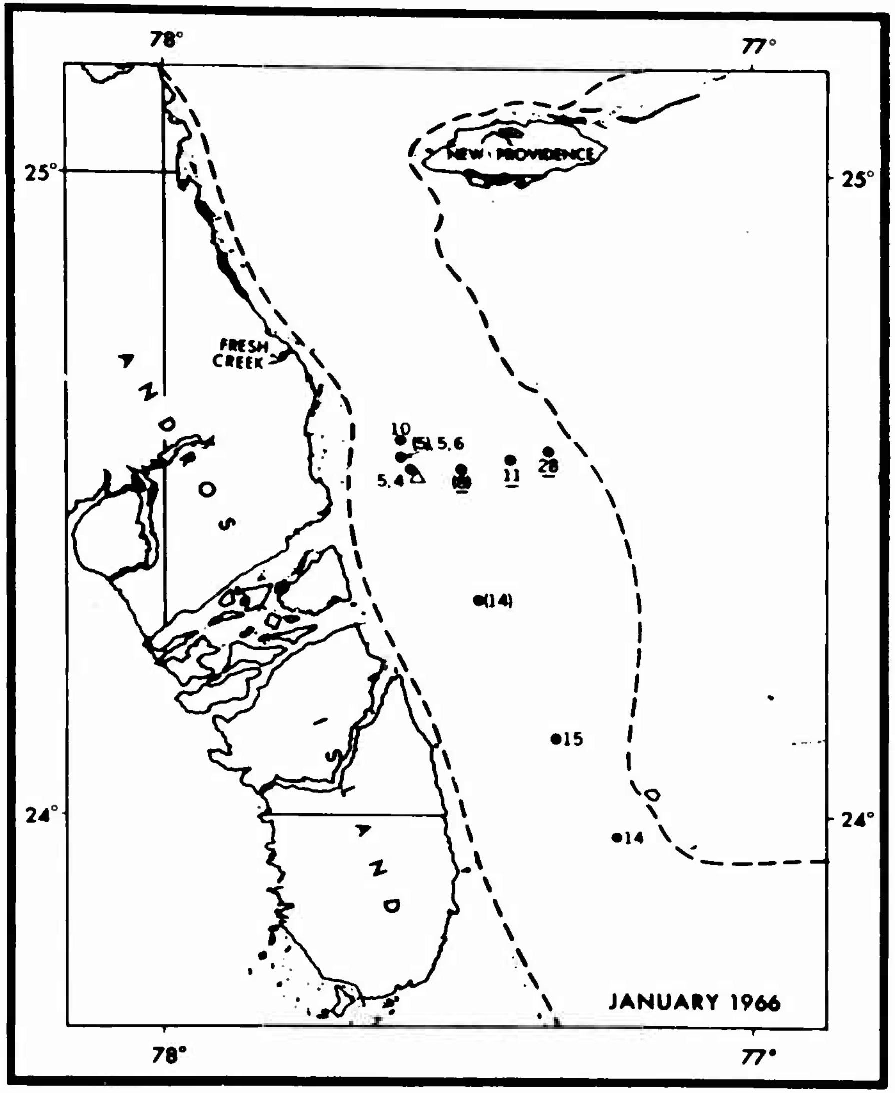
▲ Location of AUTEC Environmental Monitoring Array

Temperature Difference (x 10^{-2} °C)

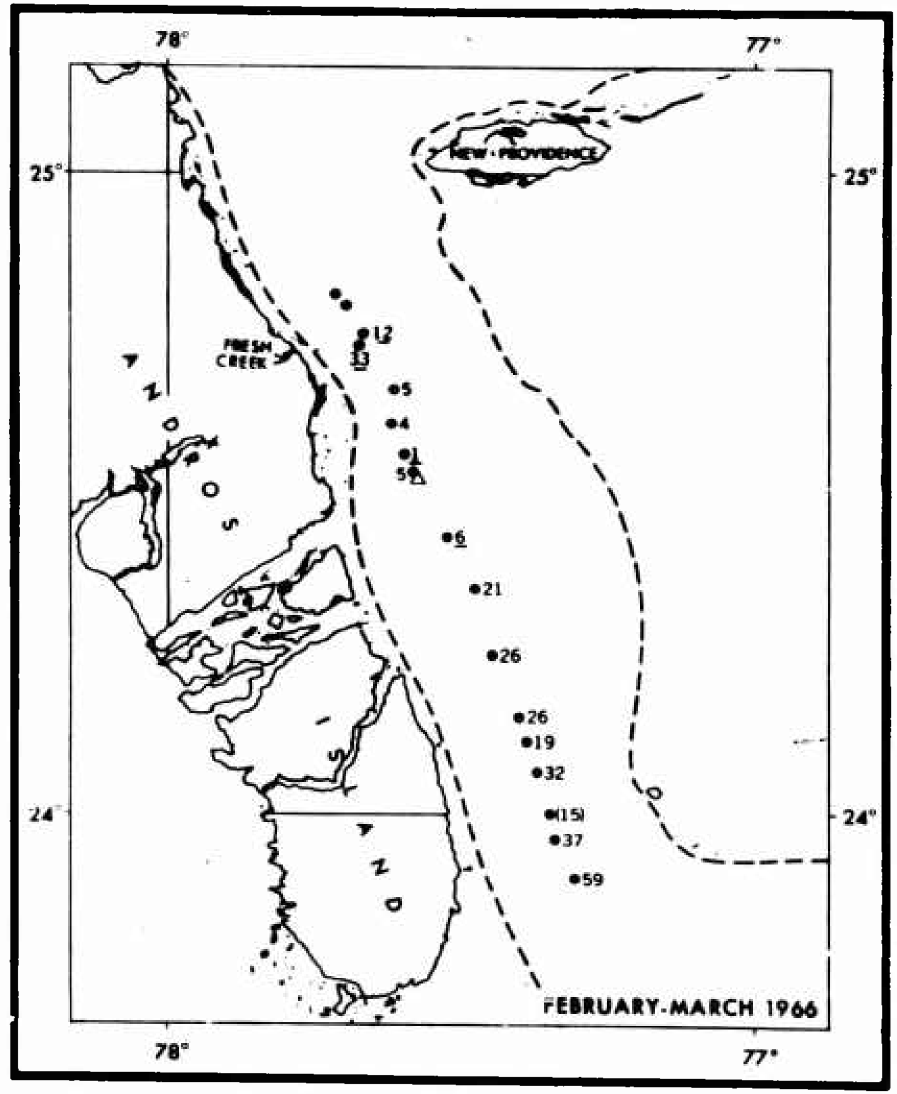
5 Positive Values

<u>5</u> Negative Values

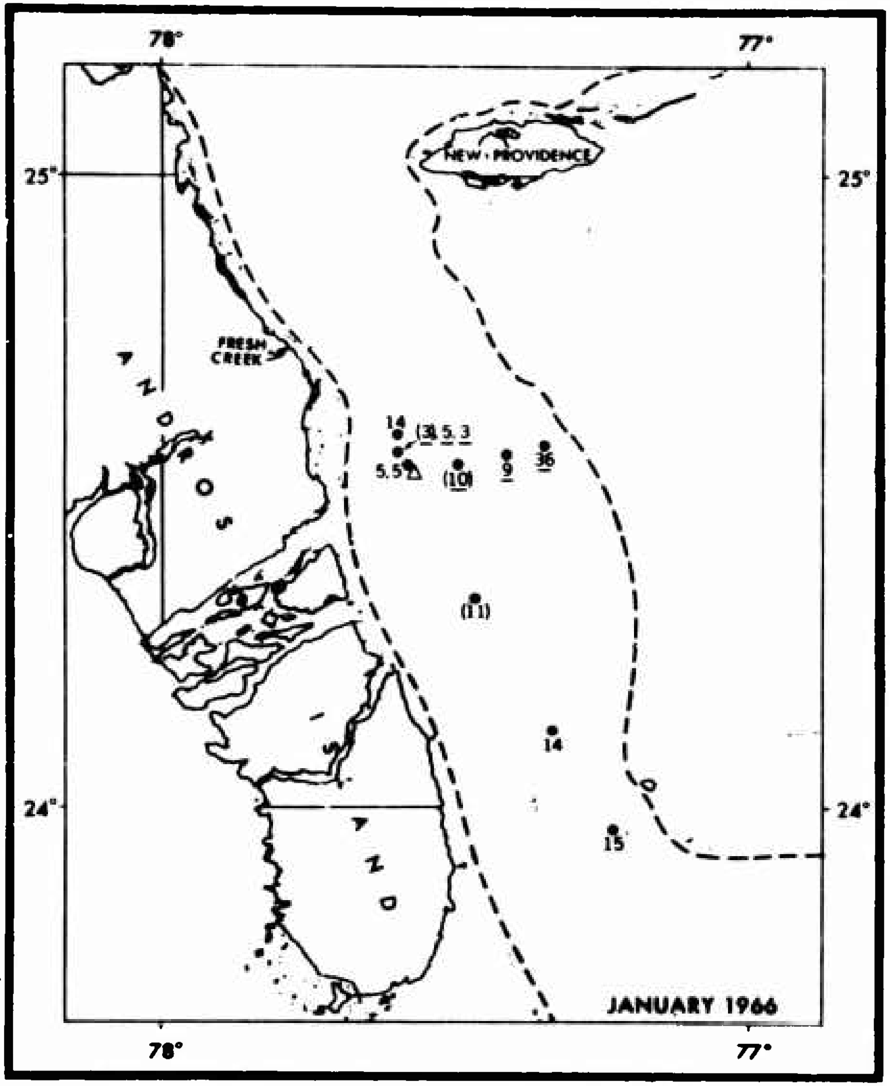
(5) Difference Based on Upcast Value From Shipboard Survey System



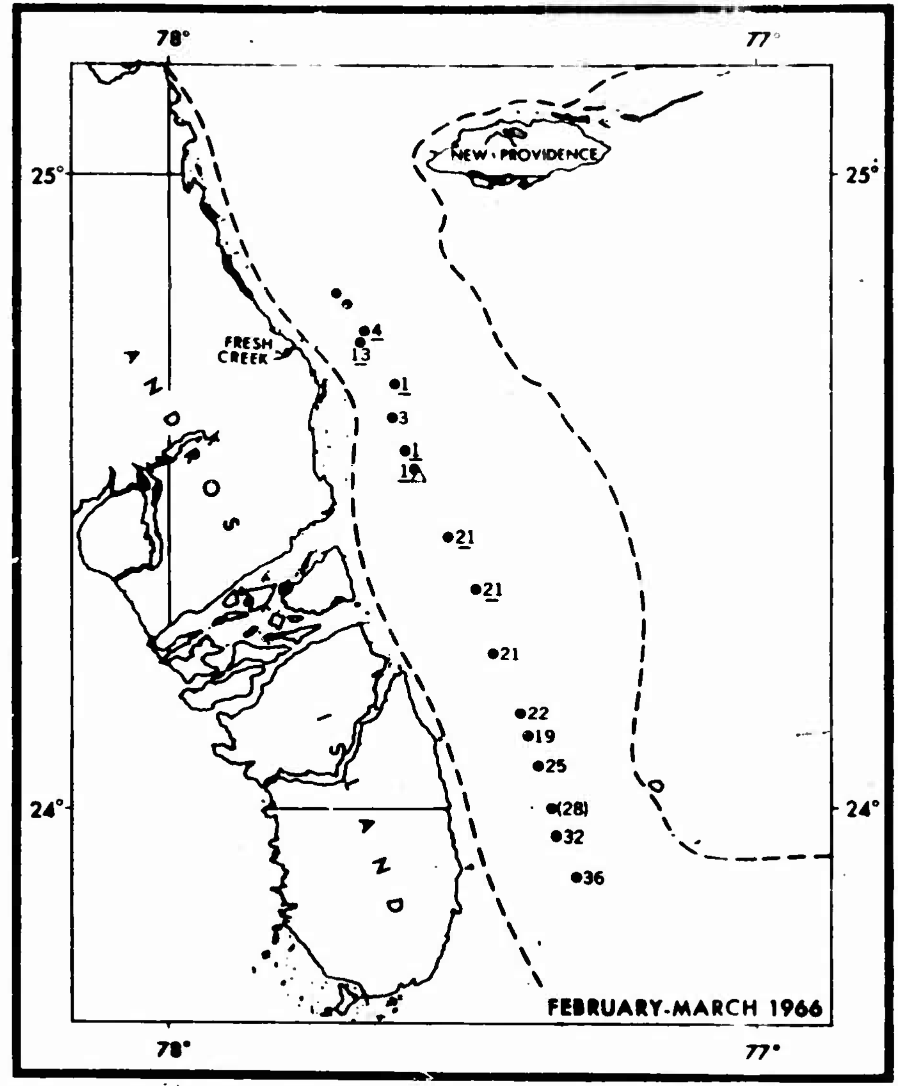
LEVEL 1 18 METERS
MEAN DIFFERENCE ($\bar{\Delta}$) = +0.02 °C
(SSS minus AEMS)



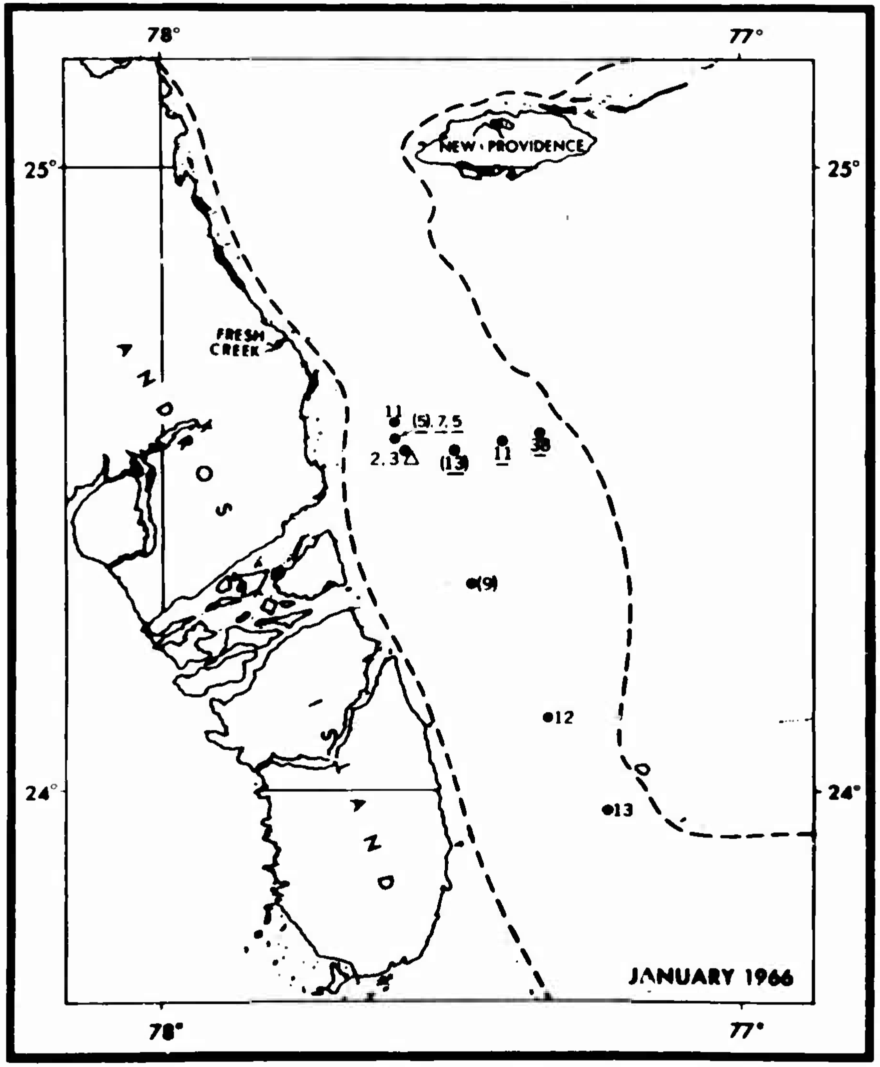
LEVEL 1 18 METERS
MEAN DIFFERENCE ($\bar{\Delta}$) = +0.13 °C
(SSS minus AEMS)



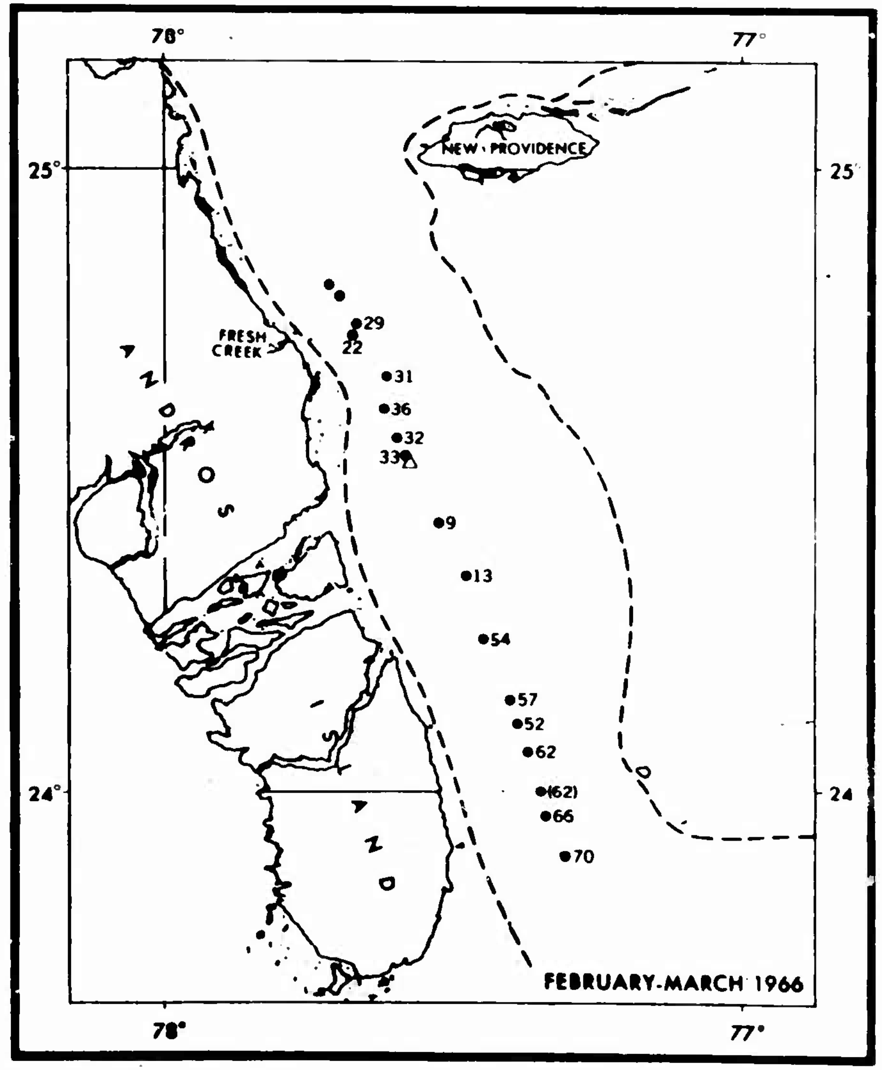
LEVEL 2 42 METERS (SENSOR 1)
MEAN DIFFERENCE ($\bar{\Delta}$) = 0 °C
(SSS minus AEMS)



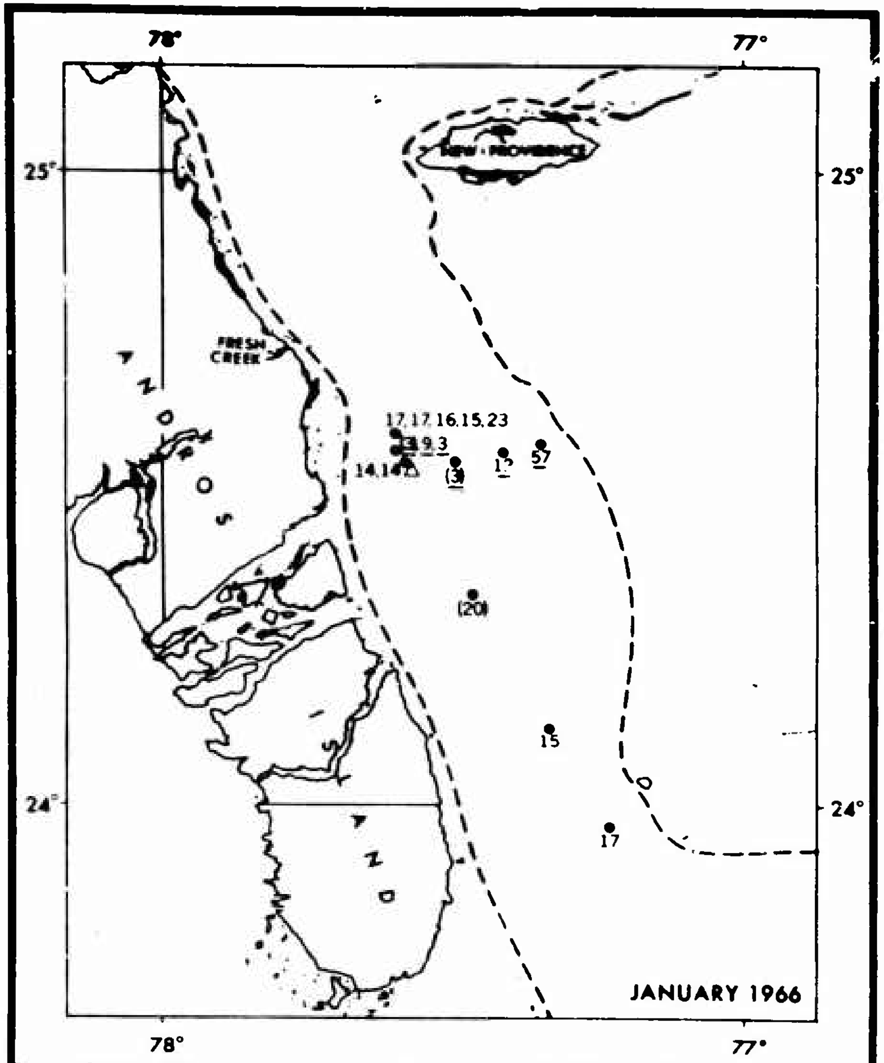
LEVEL 2 42 METERS (SENSOR 1)
MEAN DIFFERENCE ($\bar{\Delta}$) = +0.07 °C
(SSS minus AEMS)



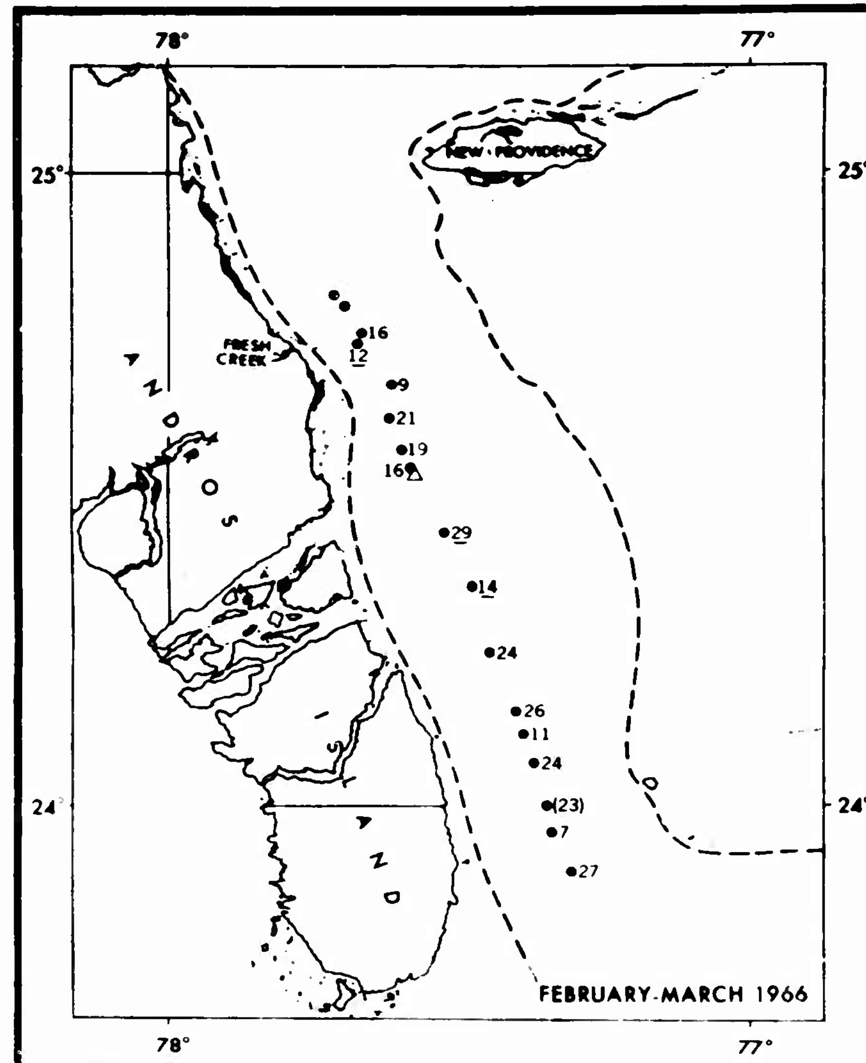
LEVEL 2 42 METERS (SENSOR 2)
MEAN DIFFERENCE ($\bar{\Delta}$) = −0.04 °C
(SSS minus AEMS)



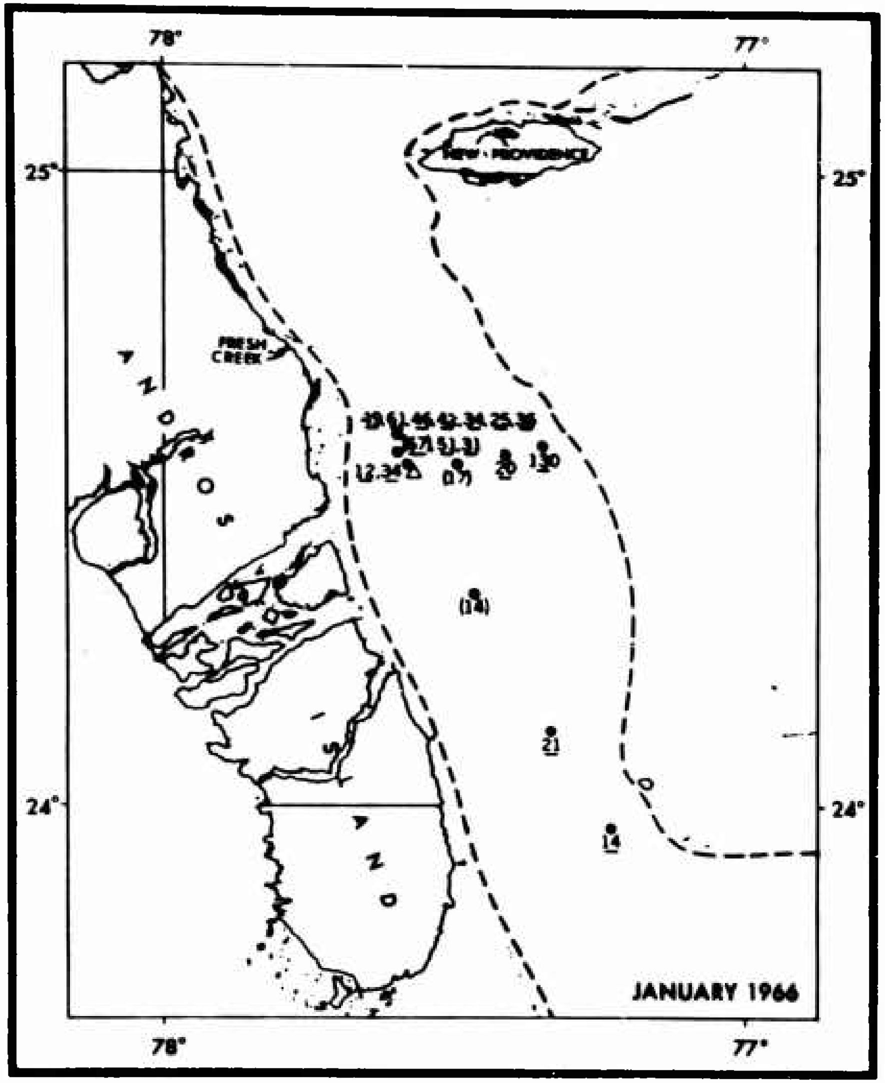
LEVEL 2 42 METERS (SENSOR 2)
MEAN DIFFERENCE ($\bar{\Delta}$) = +0.40 °C
(SSS minus AEMS)



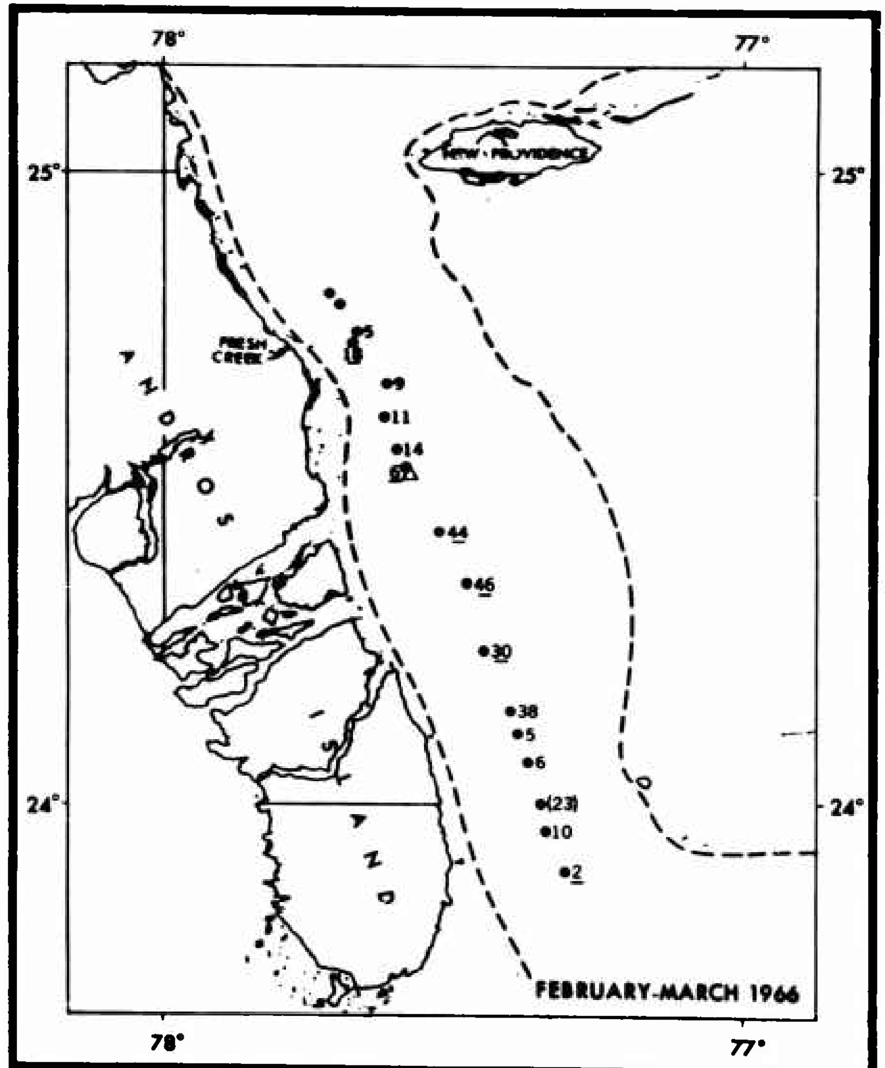
LEVEL 3 72 METERS
MEAN DIFFERENCE ($\bar{\Delta}$) = +0.05 °C
(SSS minus AEMS)



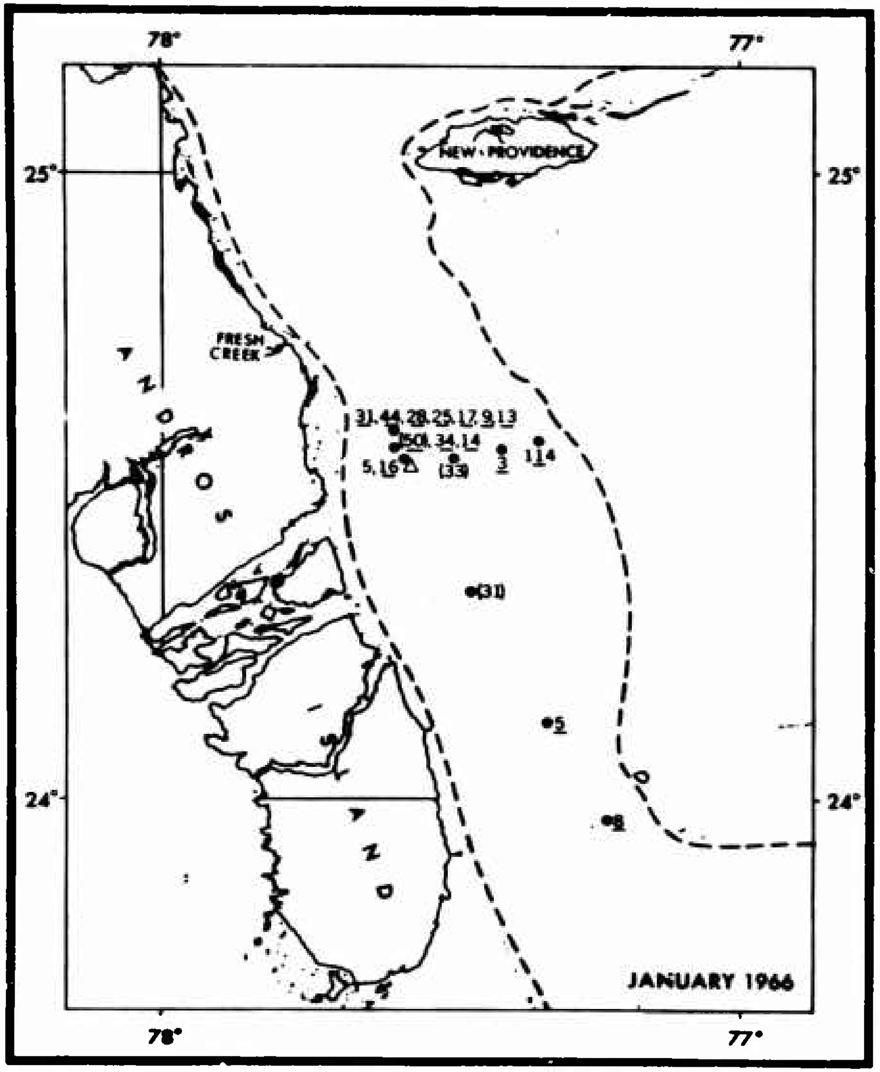
LEVEL 3 72 METERS
MEAN DIFFERENCE ($\bar{\Delta}$) = +0.10 °C
(SSS minus AEMS)



LEVEL 4 122 METERS (SENSOR 1)
MEAN DIFFERENCE ($\bar{\Delta}$) = —0.40 °C
(SSS minus AEMS)

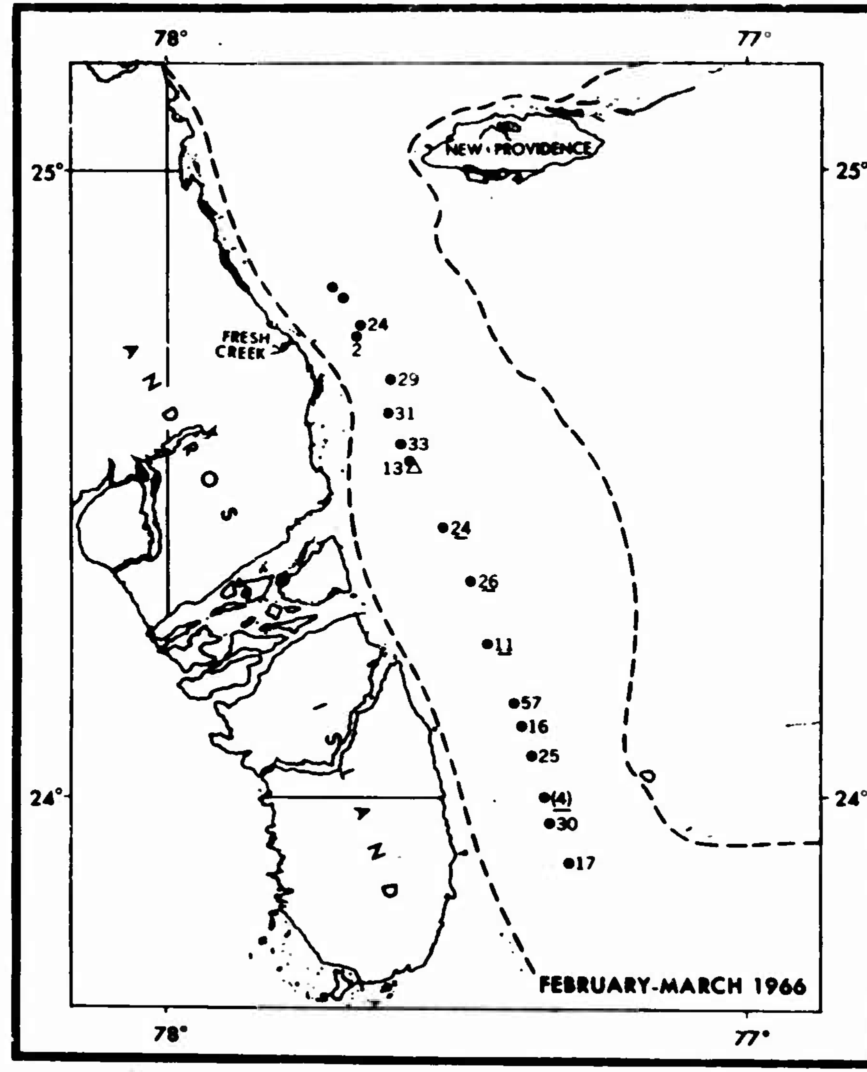


LEVEL 4 122 METERS (SENSOR 1)
MEAN DIFFERENCE ($\bar{\Delta}$) = —0.03 °C
(SSS minus AEMS)



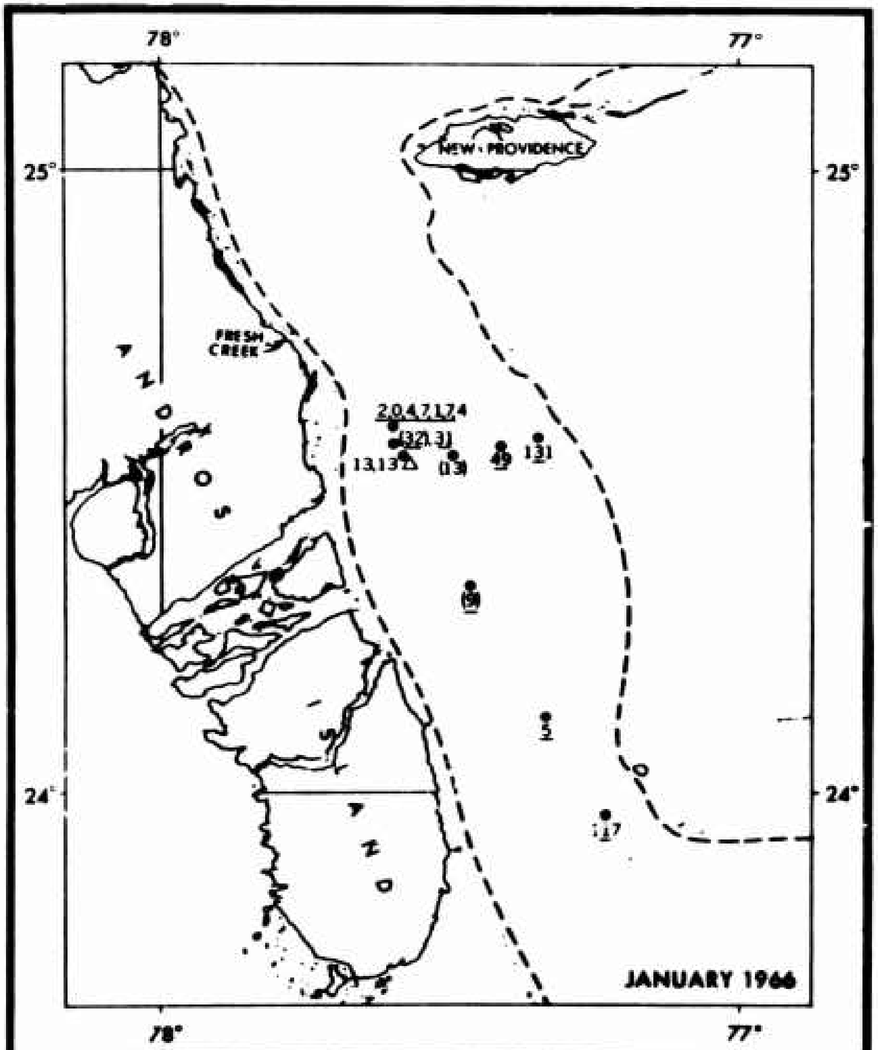
LEVEL 4 122 METERS (SENSOR 2)

MEAN DIFFERENCE ($\bar{\Delta}$) = −0.24 °C
(SSS minus AEMS)

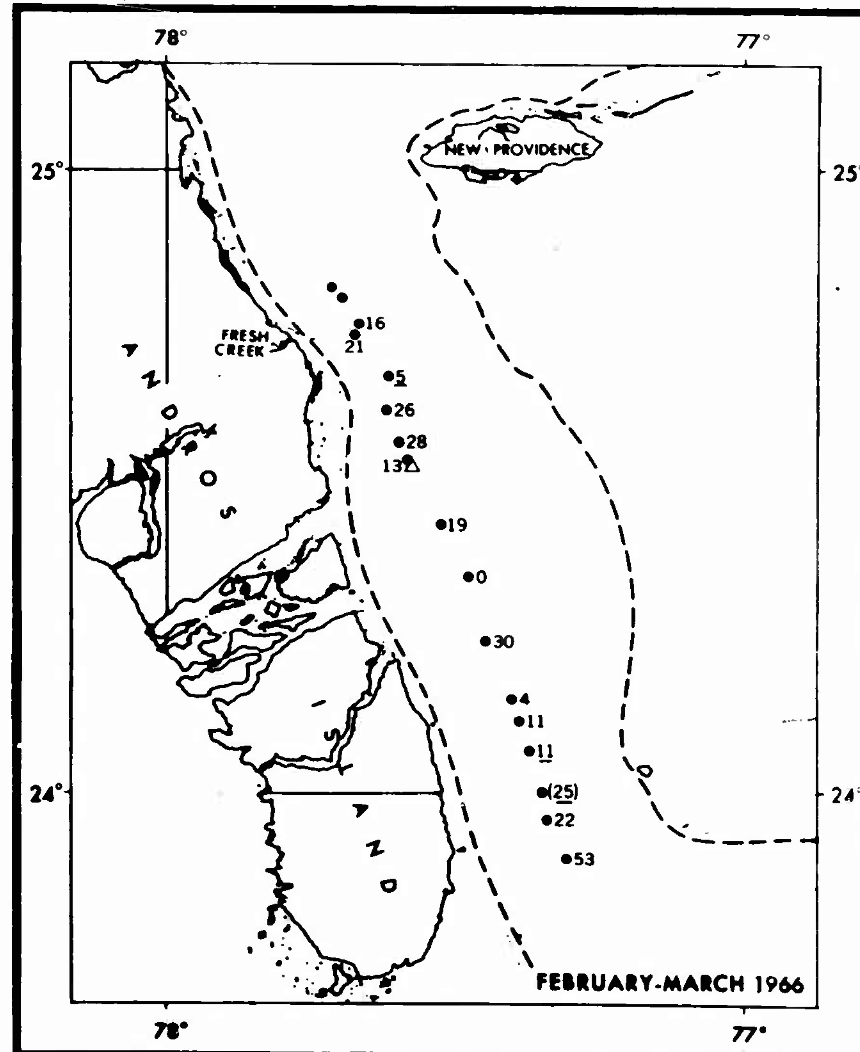


LEVEL 4 122 METERS (SENSOR 2)

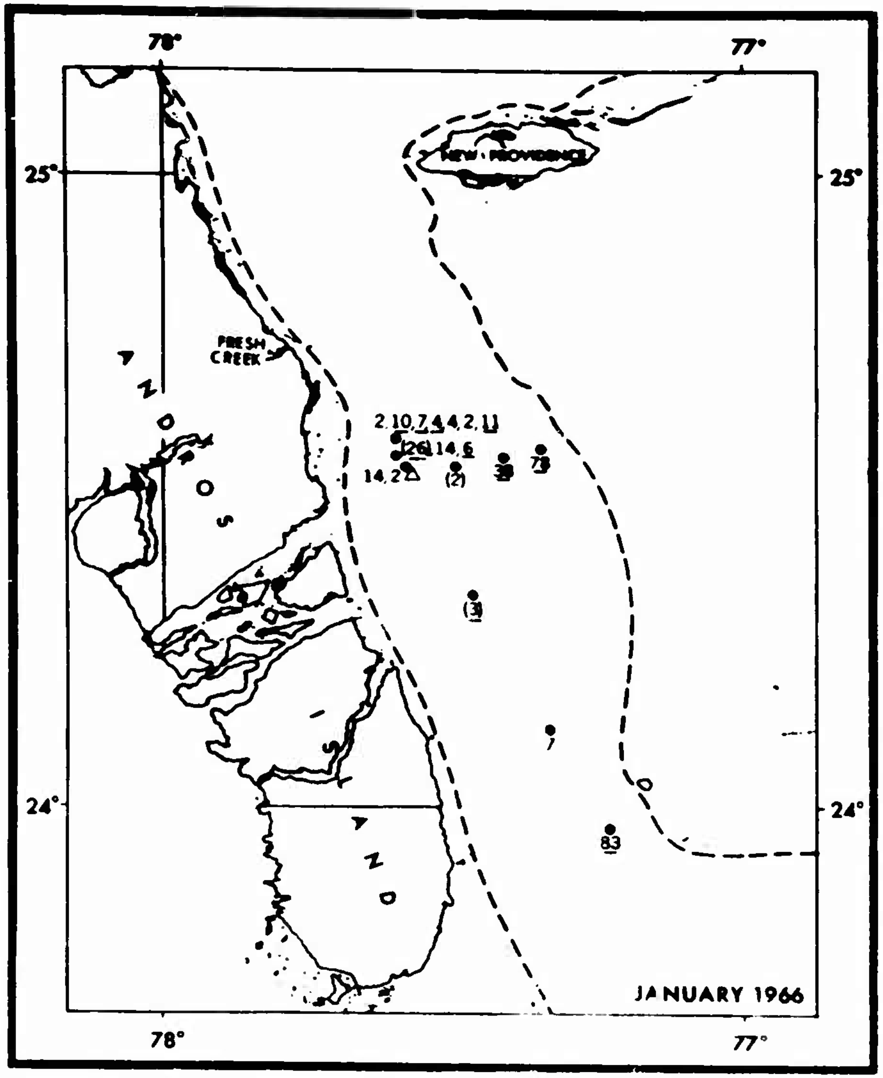
MEAN DIFFERENCE ($\bar{\Delta}$) = +0.15 °C
(SSS minus AEMS)



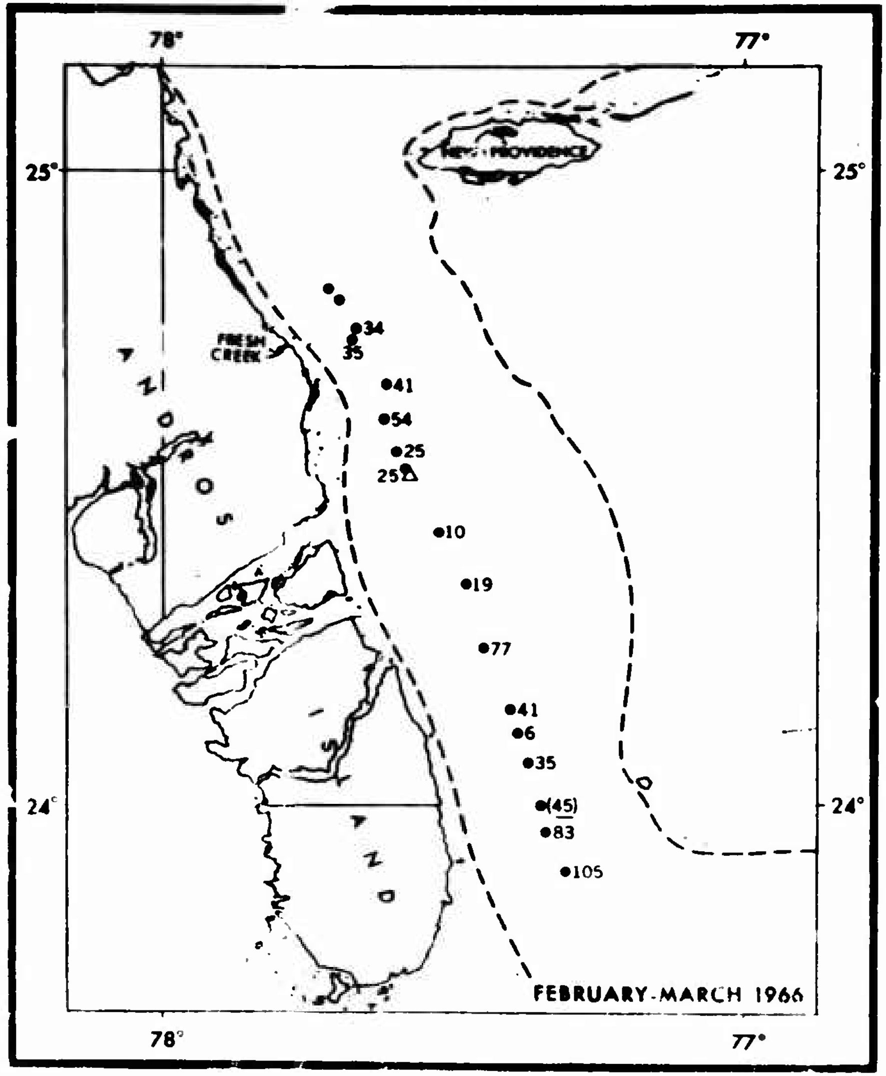
LEVEL 5 172 METERS
MEAN DIFFERENCE ($\bar{\Delta}$) = —0.23 °C
(SSS minus AEMS)



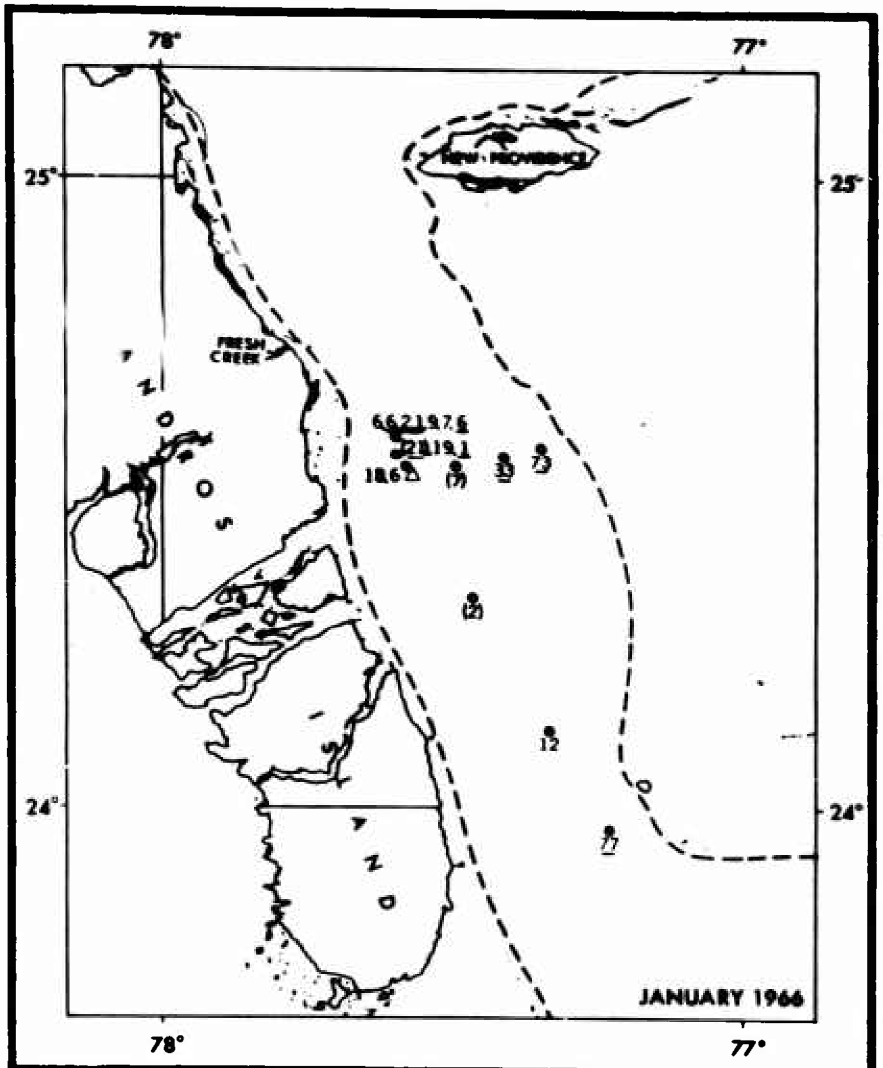
LEVEL 5 172 METERS
MEAN DIFFERENCE ($\bar{\Delta}$) = +0.16 °C
(SSS minus AEMS)



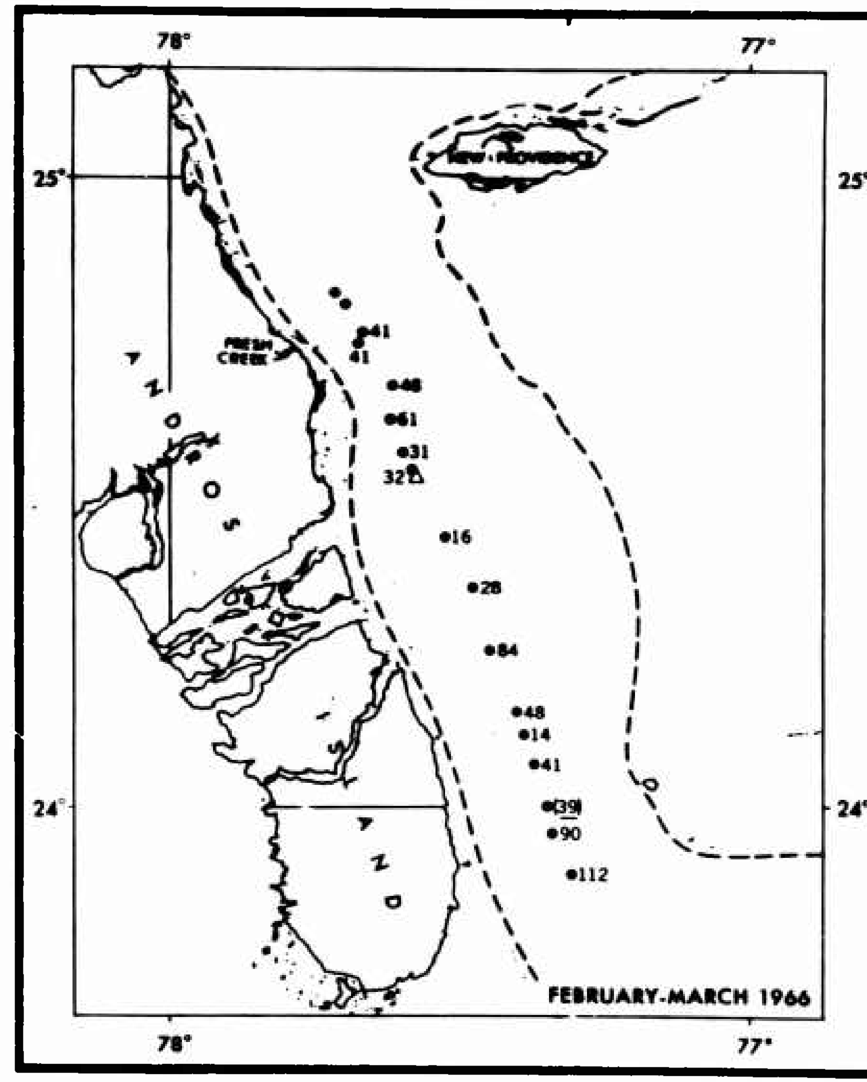
LEVEL 6 197 METERS (SENSOR 1)
MEAN DIFFERENCE ($\bar{\Delta}$) = —0.13 °C
(SSS minus AEMS)



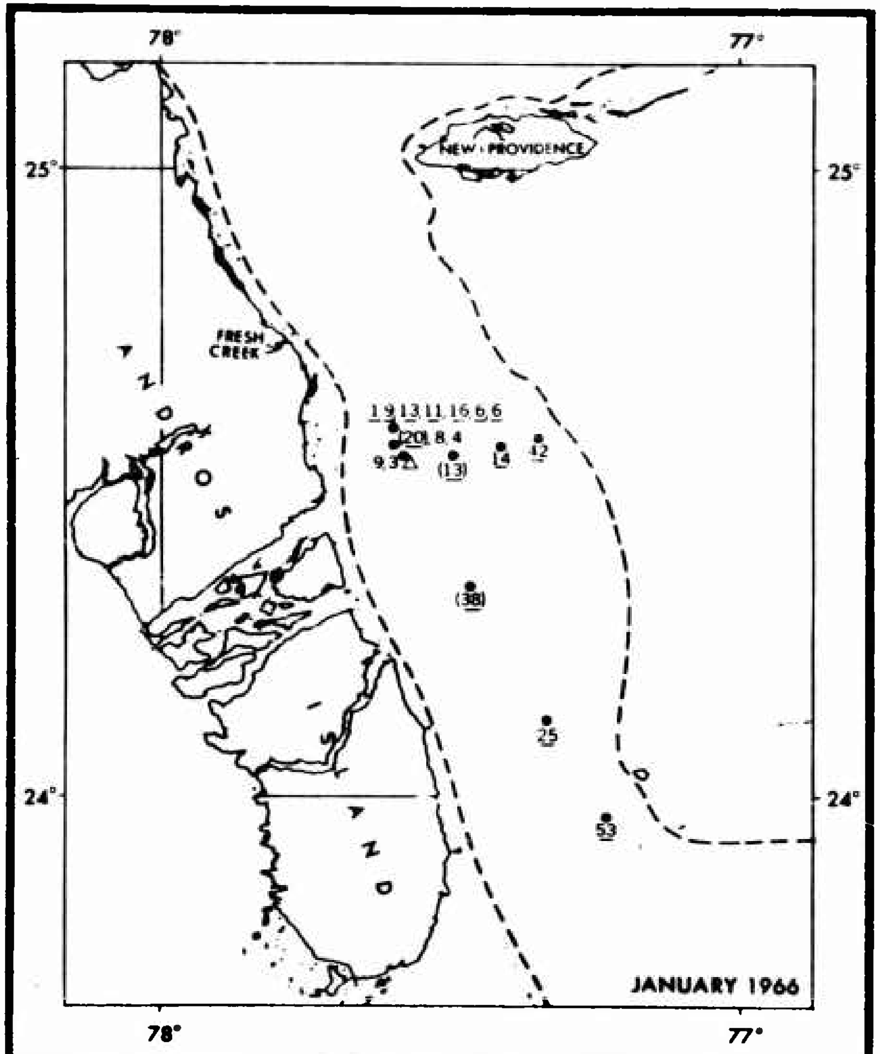
LEVEL 6 197 METERS (SENSOR 1)
MEAN DIFFERENCE ($\bar{\Delta}$) = +0.42 °C
(SSS minus AEMS)



LEVEL 6 197 METERS (SENSOR 2)
MEAN DIFFERENCE ($\bar{\Delta}$) = —0.08 °C
(SSS minus AEMS)

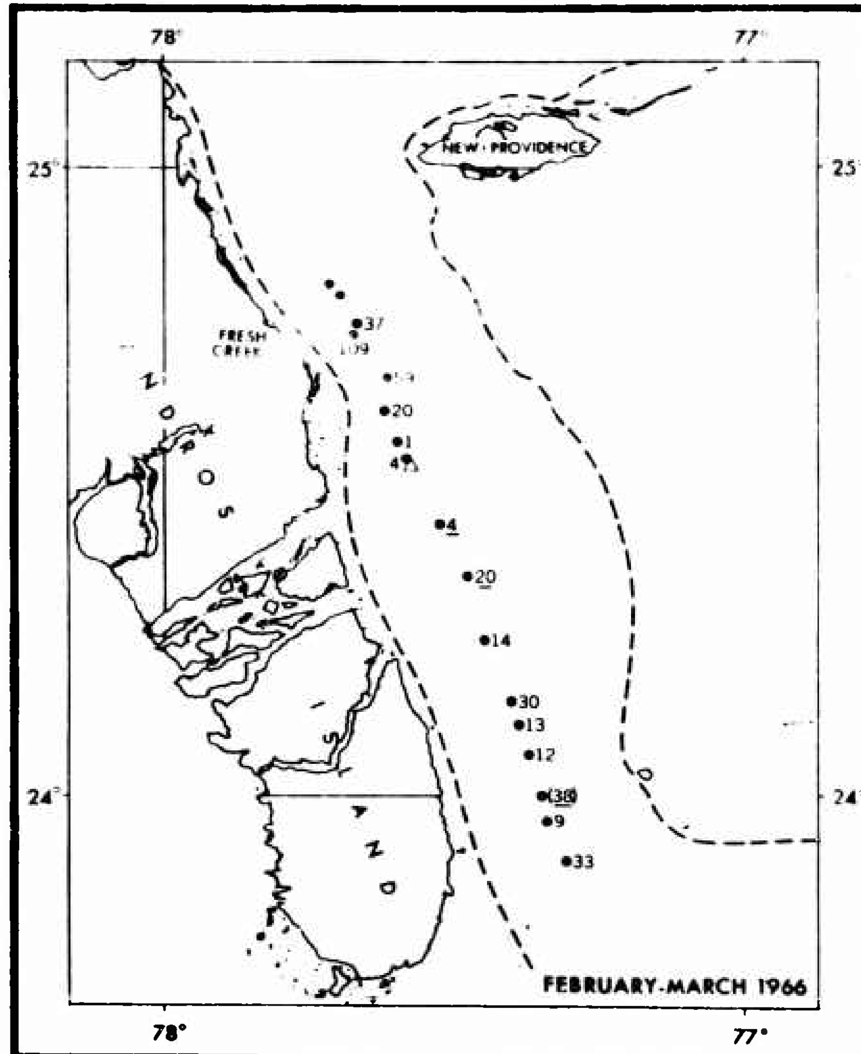


LEVEL 6 197 METERS (SENSOR 2)
MEAN DIFFERENCE ($\bar{\Delta}$) = +0.49 °C
(SSS minus AEMS)



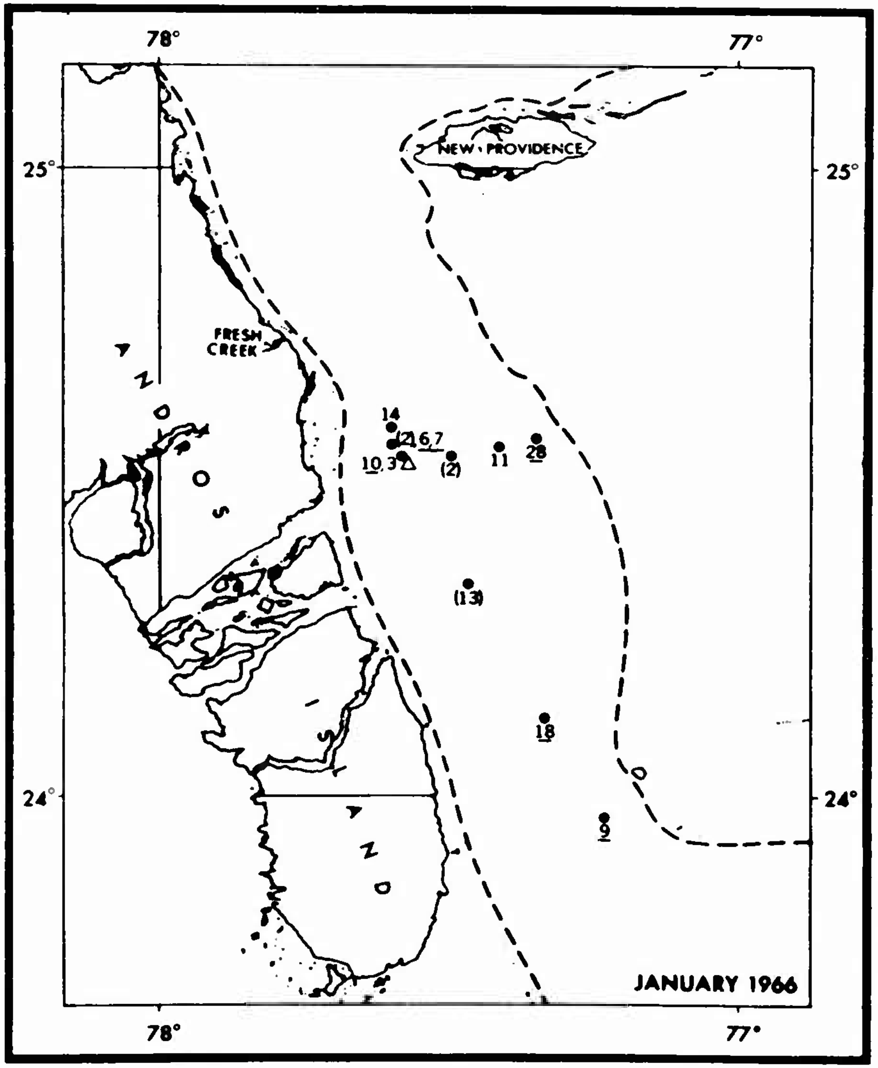
LEVEL 8 247 METERS

MEAN DIFFERENCE ($\bar{\Delta}$) = —0.11 °C (SENSOR 1)
(SSS minus AEMS) = —0.07 °C (SENSOR 2)



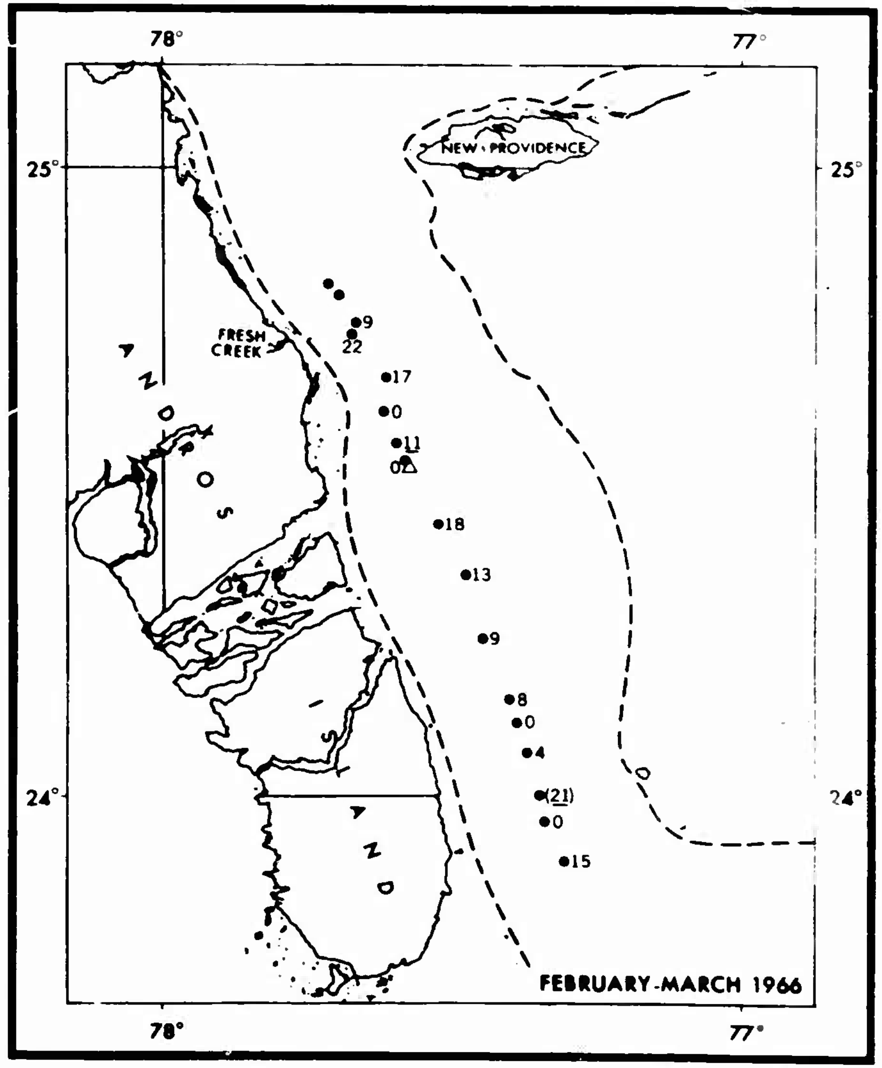
LEVEL 8 247 METERS

MEAN DIFFERENCE ($\bar{\Delta}$) = +0.23 °C (SENSOR 1)
(SSS minus AEMS)



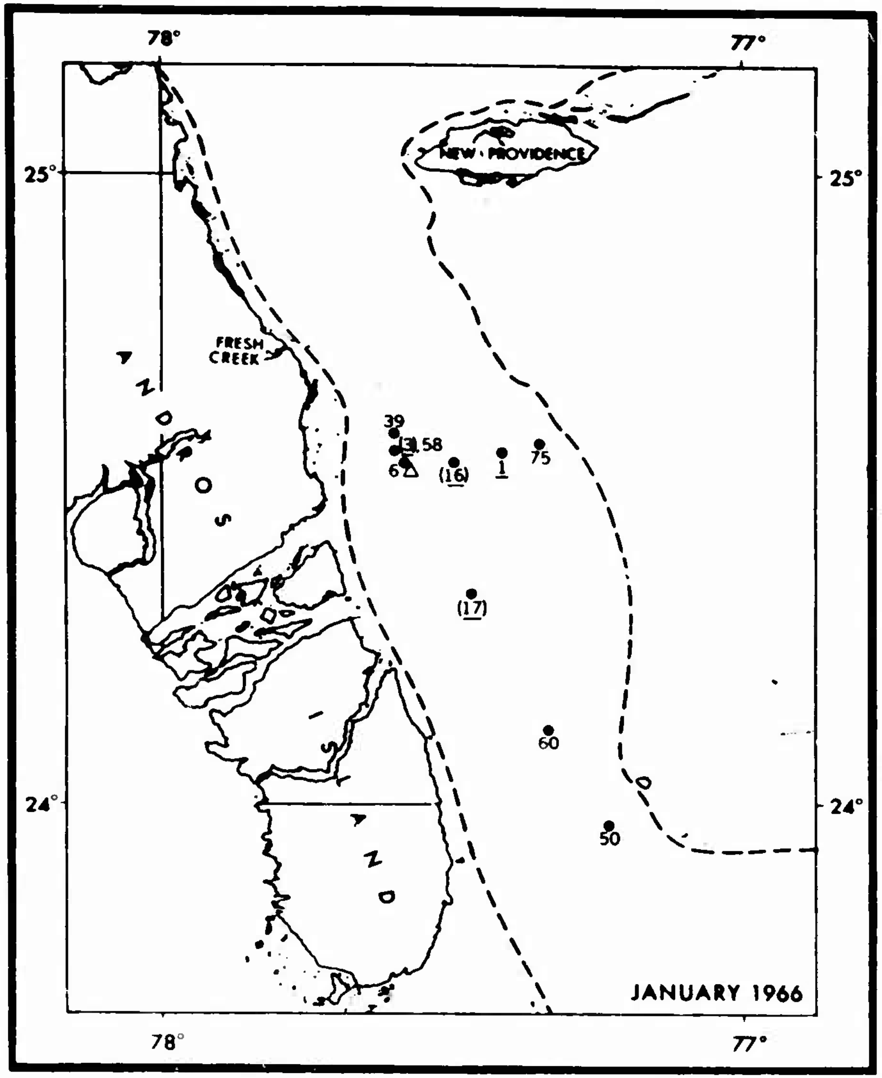
LEVEL 9 347 METERS

MEAN DIFFERENCE ($\bar{\Delta}$) = —0.06 °C
(SSS minus AEMS)



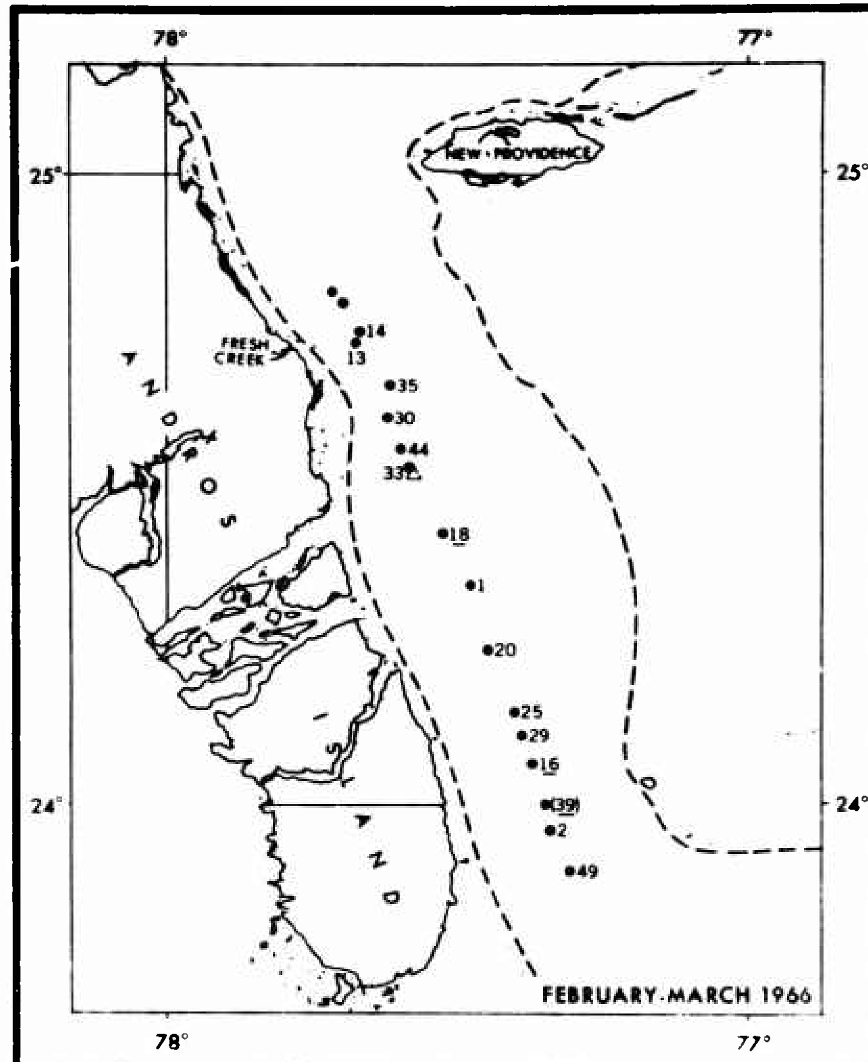
LEVEL 9 347 METERS

MEAN DIFFERENCE ($\bar{\Delta}$) = +0.07 °C
(SSS minus AEMS)



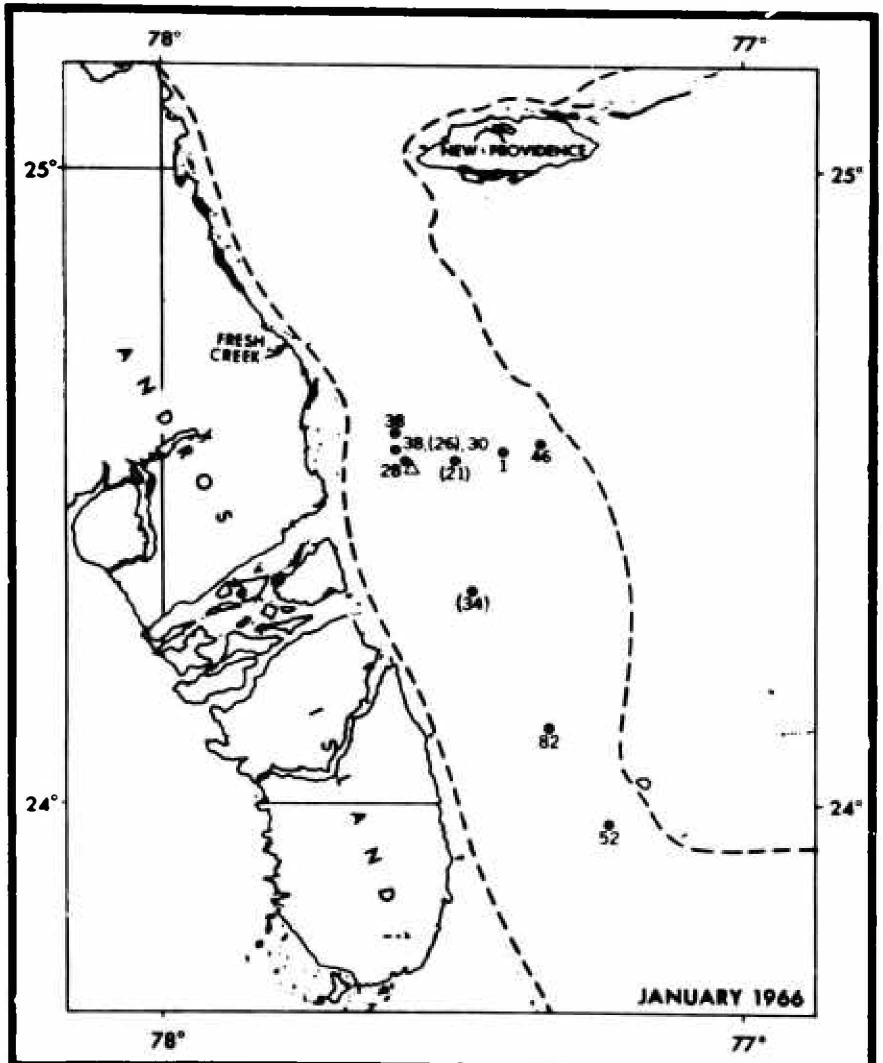
LEVEL 10 647 METERS

MEAN DIFFERENCE ($\bar{\Delta}$) = +0.41 °C (SENSOR 1)
(SSS minus AEMS) = +0.40 °C (SENSOR 2)



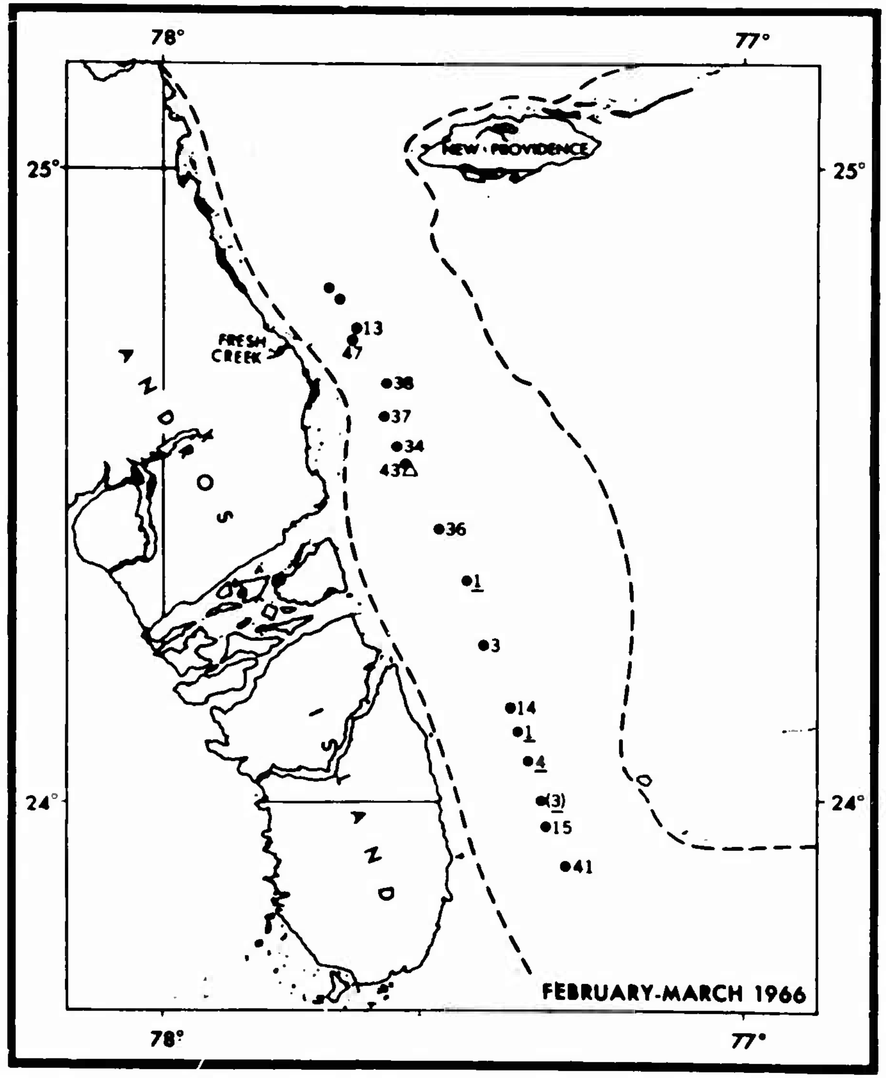
LEVEL 10 647 METERS

MEAN DIFFERENCE ($\bar{\Delta}$) = +0.19 °C (SENSOR 1)
(SSS minus AEMS) = +0.19 °C (SENSOR 2)



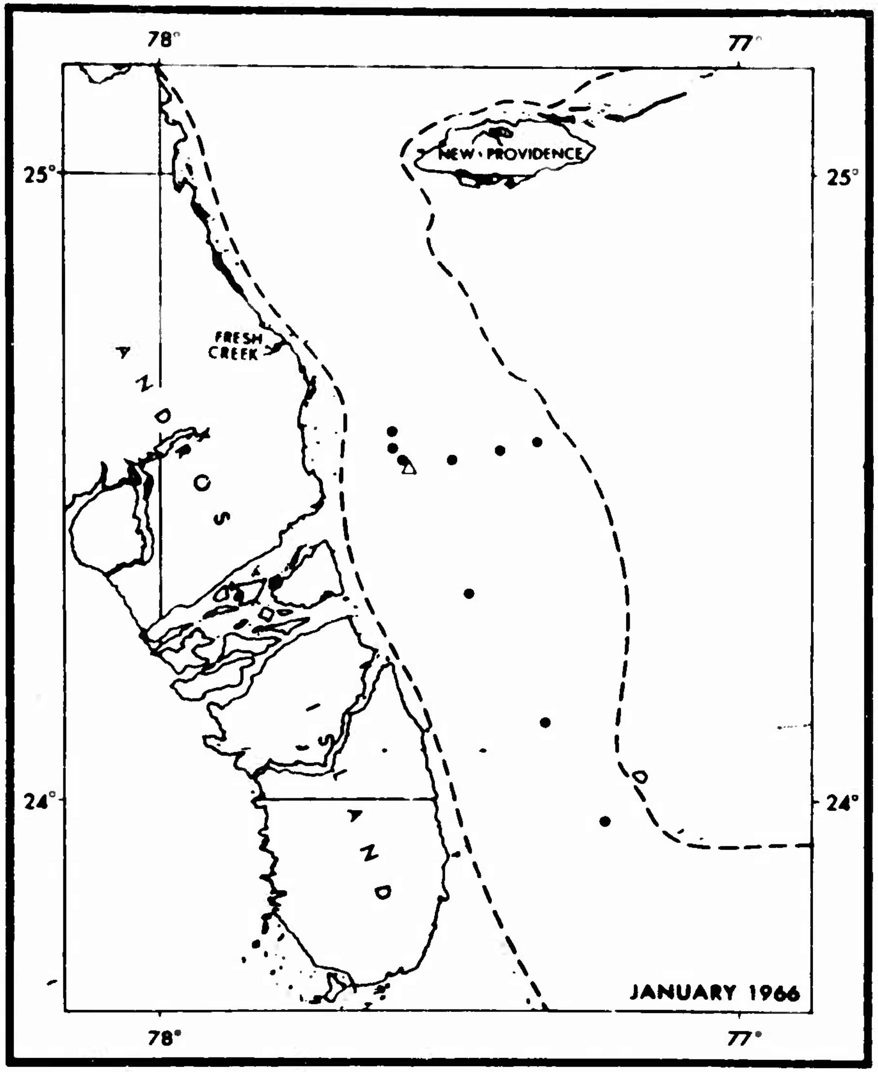
LEVEL 11 797 METERS

MEAN DIFFERENCE ($\bar{\Delta}$) = +0.39 °C
(SSS minus AEMS)

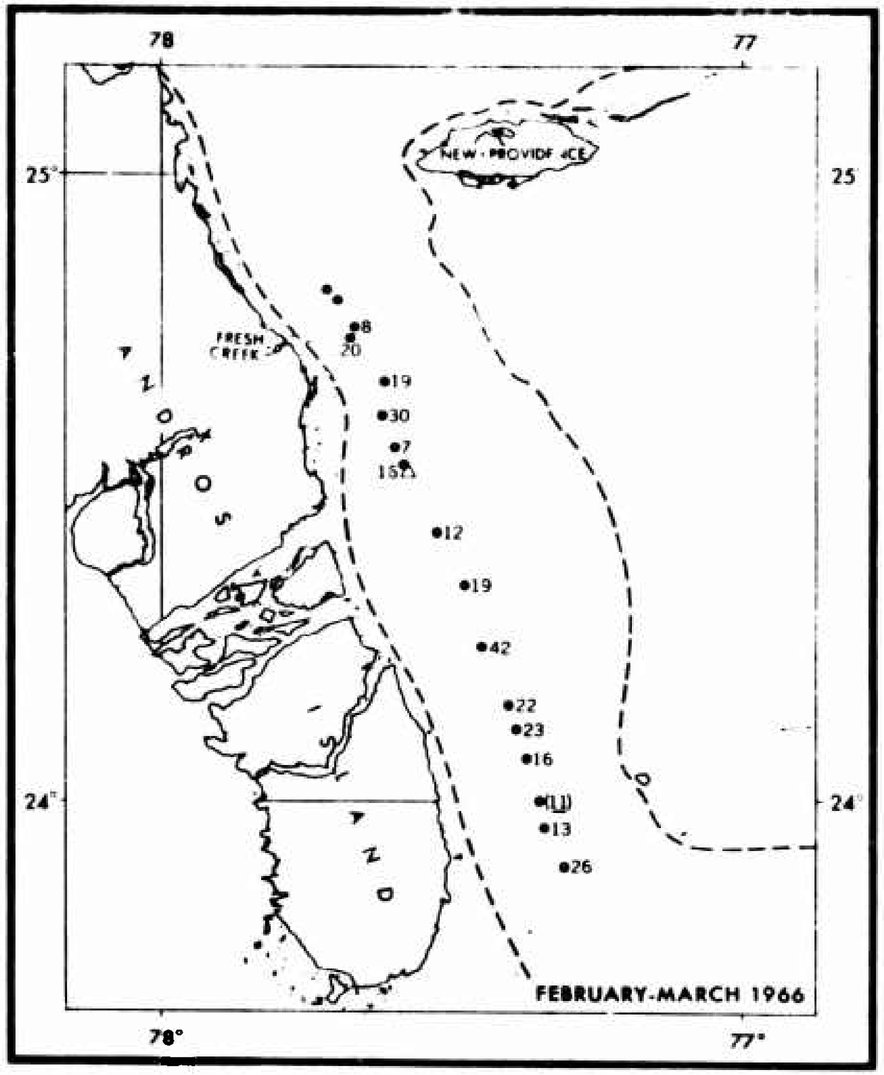


LEVEL 11 797 METERS

MEAN DIFFERENCE ($\bar{\Delta}$) = +0.22 °C
(SSS minus AEMS)

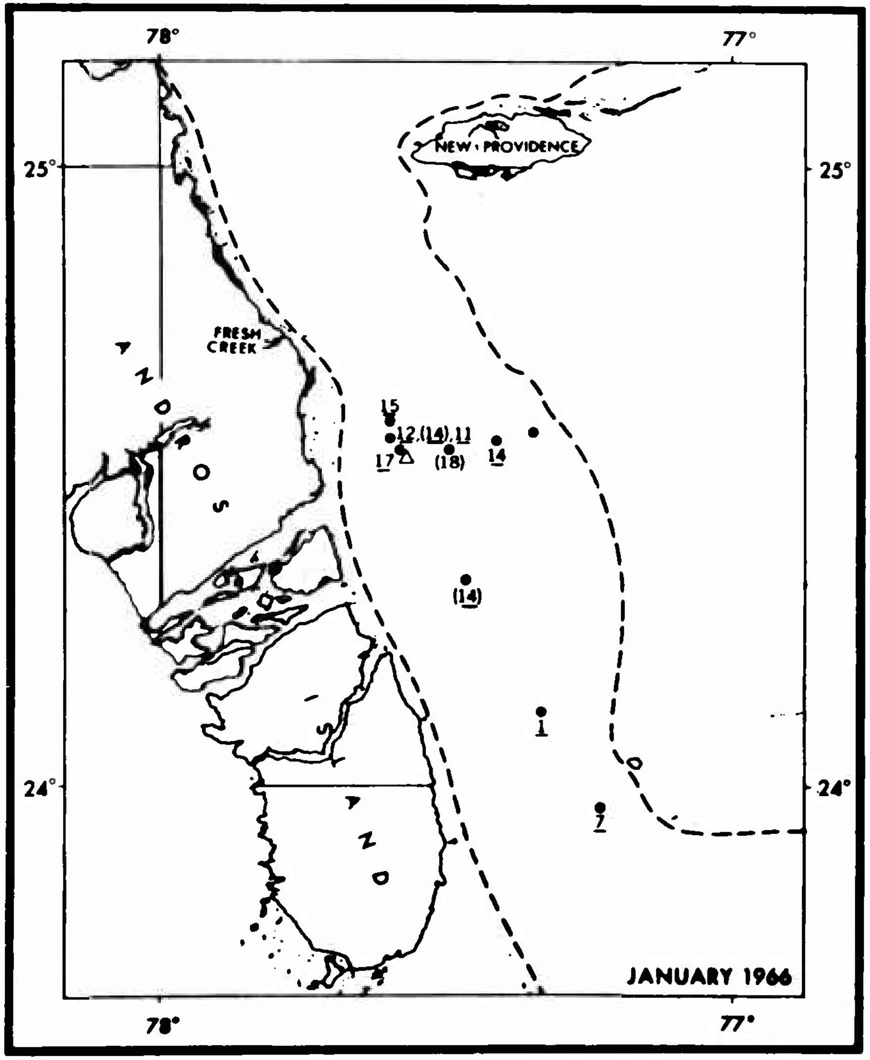


LEVEL 12 NO DATA (ARRAY SENSORS ERRATIC)



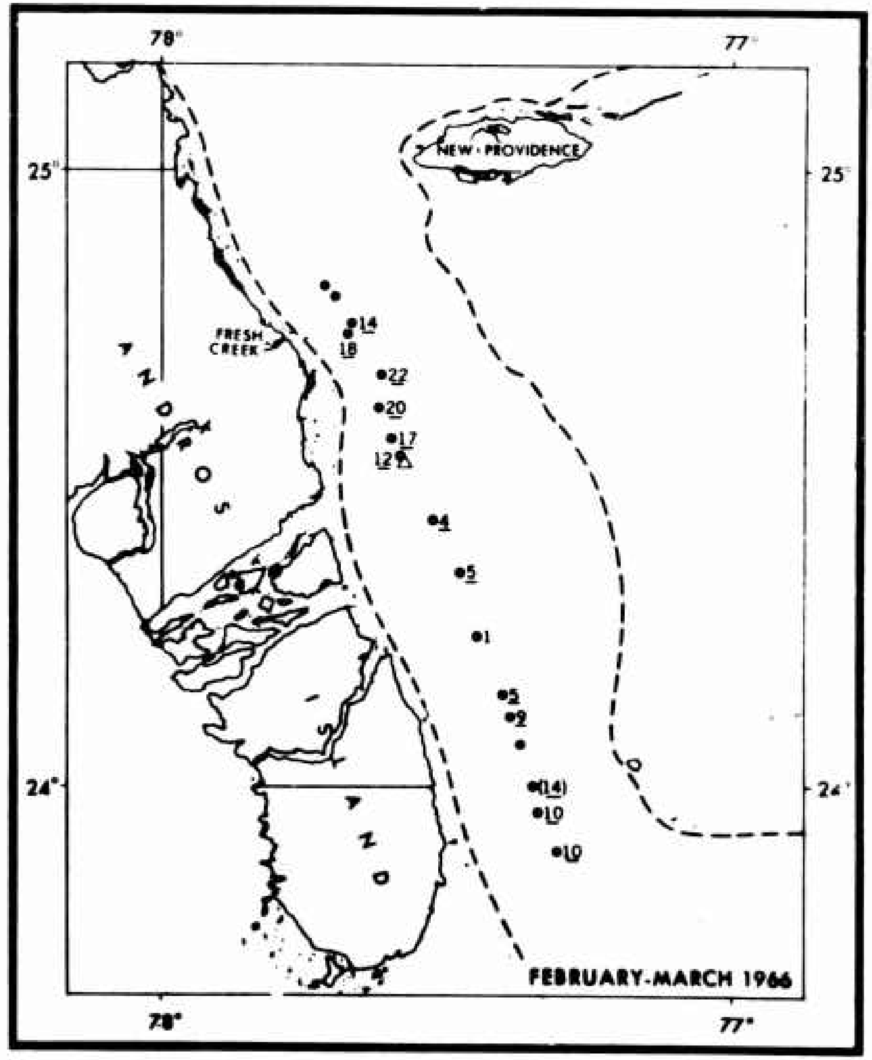
LEVEL 12 997 METERS (SENSOR 1)

MEAN DIFFERENCE ($\bar{\Delta}$) = +0.20 °C
(SSS minus AEMS)



LEVEL 13 1222 METERS

MEAN DIFFERENCE ($\bar{\Delta}$) = —0.11 °C
(SSS minus AEMS)



LEVEL 13 1222 METERS

MEAN DIFFERENCE ($\bar{\Delta}$) = —0.11 °C
(SSS minus AEMS)

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13. ABSTRACT

Comparisons of two sets of data collected in the Tongue of the Ocean (TOTO), one from the fixed-site AUTEC Environmental Monitoring Array at Site 2, the other from varying-site, on-station drops of the Shipboard Oceanographic Survey System (SOSS) from aboard the USNS SILAS BENT (AGS-26), were made for 3-7 January and 27 February through 4 March, 1966. The comparisons reveal that both of these highly automated systems complement one another very well, despite the different approach each one takes to oceanographic sampling. Because the SOSS offers the advantage of horizontal flexibility, sampling locations of the "fish" were spaced at varying distances from the array in order to derive significant information on horizontal temperature gradients in the TOTO.

This report summarizes the results of these synoptic temperature-depth data comparisons and briefly discusses the significance of the data comparisons in terms of horizontal temperature gradients in the TOTO.

Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Tongue of The Ocean (TOTO) Shipboard Oceanographic Survey System (SOSS) environmental monitor AUTEC Temperature sensing						

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(PAGE 2)

Security Classification